# Experimental and Research Station,

## Nursery & Market Garden Industries' - - Development Society, Limited. - -

Turner's Hill, Cheshunt, Herts.

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# Thirteenth Annual Report, 1927.

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# *Introduction.*

THE Experimental and Research Station was inaugurated in 1914 under the auspices of the Nursery and Market Garden Industries' Development Society, when its early development was retarded by the World upheaval which followed. The conclusion of hostilities brought additional workers to the Station, and its activities have developed beyond all expectations. It is a pleasure to report that during the present year continued progress has been achieved in all branches.

Growers of glasshouse plants, like all horticulturalists, have their problems to face and difficulties to overcome, and the Experimental Station was erected by a small body of enthusiasts who, in 1914, had decided to call Science to their aid. The wisdom of their policy has been amply confirmed by the service rendered to the industry by the Station.

From small beginnings the Station has developed a fully equipped laboratory housing a scientific staff capable of dealing with the problems which may be submitted by glasshouse growers from time to time. In addition there are six cucumber houses, eleven tomato houses, one isolation house, a chambered house suitable for temperature experiments, and two entomological glasshouses.

During the current year a plot of land, some $1\frac{2}{3}$ acres in extent, which adjoins the Station property on the north side, was purchased for the purpose of erecting a Director's house, and to provide space for additional glasshouses. The dwelling house will be completed during 1928, and it is hoped that funds may be forthcoming in the near future to permit the erection of glasshouses where crops, other than the cucumber and tomato, can be grown. When this is done, the Station

will be in a position to experiment with such crops as grapes, roses, carnations, ferns, melons and mushrooms, as well as certain decorative pot plants.

Anyone, able and willing to finance this project would be a public benefactor, for the Station, started to benefit a local industry, has now become of national service, and the need for experiments with all glasshouse plants is becoming increasingly greater each year.

Membership of the Society, under whose auspices the experiments are conducted, is open to all growers and interested persons, and subscriptions are payable at the rate of two guineas per annum for each acre of glass cultivated by the subscriber. In return members receive future publications and any advice which is available. Members are constantly being enrolled, but new members are urgently needed both to provide additional funds for research, and to obtain complete co-operation in controlling the various diseases and pests common to glasshouse plants. A serious outbreak over a wide area must be fought by all growers within the area ; isolated attacks are bound to fail.

**Evening Discussions.**

The evening lectures for nursery owners and employees, begun in 1925, were converted into discussions, and the following subjects were chosen :—

Oct. 20th.—The cultivation of cottage gardens and allotments.

Nov. 3rd.—Soil sterilisation.

Nov. 17th.—The heating of glasshouses.

Dec. 1st.—Soil fertility.

Dec. 15th.—Can nursery water supplies and methods of watering be improved ?

Jan. 26th.—Evolution.

Feb. 9th.—Poultry.

Feb. 23rd.—The construction of glasshouses.

March 9th.—Open night.

These meetings were well attended and continue to stimulate interest in the scientific side of horticulture. Through the generosity of the Lea Valley Growers' Association light refreshments were served during the interval between the opening speeches and the general discussion.

It is obvious that the skill and knowledge of glasshouse workers is a contributing factor to the success of any nursery, and the wise grower will appreciate the efforts of the Station to educate the workers in the general principles of horticulture and the latest discoveries of applied science. It is hoped that nursery owners will attend these discussions more frequently in the future and so stimulate the interest of the workers.

**Lectures and Exhibits.**

Invitations to lecture on glasshouse problems have been received from organised bodies of nurserymen in many parts of the country, and have been undertaken by the Director and the Entomologist. Most of the meetings have been well attended and stimulating discussions resulted in every case. The Director also visited Guernsey in 1926 and 1927. Exhibits have been sent to the Royal Horticultural Society's Spring Show at Chelsea, and have proved a source of interest to horticulturalists. A special steaming exhibit was prepared for 1927.

**Administration.**

The administrative work in connection with the Station is developing out of all proportion to the office staff, and if the present standard of efficiency is to be maintained additional help must be obtained.

Ordinary office routine, reception of visitors, telephone calls and the typewriting connected with the outside experiments require a great deal of time, and, with the compilation of crop records and official reports, the work has advanced beyond one person's capacity.

Miss Helen Marchant, who had faithfully served the Experimental Station as Secretary almost since its inception, and had also acted in the same capacity to the Lea Valley

Growers' Association and Nursery Trades, Ltd., resigned her post on the 31st March, 1927. Miss Marchant's resignation, owing to family bereavement, was received with sincere regret, and a presentation was made to her as a token of appreciation and esteem by those growers whose interests she had served so well. We are glad to welcome Miss Gladys Bell as her successor.

**Grants.**

The Empire Marketing Board has generously provided a capital grant of £1,600 for the erection of four new glasshouses, and a maintenance grant of £1,660 a year in support of the investigation of suitable control measures for the red spider and allied mites, tomato mildew, and mosaic disease, together with the cultivation and distribution of the white fly parasite, *Encarsia formosa*.

The Lea Valley Growers' Association have also granted a sum of £200 per year for the purpose of studying the activities of the red spider mite on commercial nurseries.

Our grateful thanks are tendered to those bodies for their generous assistance.

**Current Investigations.**

Manurial and crop management trials with the tomato have been continued.

The stable manure experiment, started in 1926, was repeated and the previous results confirmed. Under the conditions of the experiment dressings above 15 tons per acre gave no appreciable return. It must be remembered, however, that the soil in question has been down to tomatoes for twelve years without sterilisation and the root action is not good ; the crop this year averaged 34 tons per acre. The type of crop, however, is similar to that of a number of nurseries in different parts of the country, where steaming is not practised, and where heavy dressings of stable manure are given. The results suggest that on many nurseries a dressing above 15 tons per acre is unnecessary, and growers should take steps to test this point under their own conditions. Plants with a better root system, such as those on new soil or sterilised soil, may react to heavier applications of stable manure. This will be tested in the future.

The watering experiment, commenced in 1926, has also been repeated, but the soil was steamed for 1927, and the results of the two years vary somewhat. In 1926, the increased quantities of water did not affect the crop, whereas in 1927 some benefit was obtained by increasing the normal quantity by 50 per cent. The experiment shews that the amount of water required by the crop depends upon the condition of its root system.

Some evidence has been obtained to show that the tomato crop requires a good deal of potash prior to " stopping," and that afterwards suitable dressings of a nitrogenous fertiliser, such as dried blood, are advantageous.

The beneficial effect of incorporating straw with the soil prior to planting has been repeated, and experiments along similar lines are being arranged for 1928.

The variety trials have confirmed previous findings that the varieties Up-to-date and Sterling Castle are highly resistant to " Mildew," *Cladosporium fulvum*. As these are not so good as some of the well-known commercial varieties, an attempt is being made to raise a new variety which will combine resistance to mildew with commercial excellence.

The cucumber experiments concerned with the base or soil upon which the beds are placed have yielded important results, which are detailed in the section devoted to them. The beneficial effect of steaming the base each year has been amply confirmed. The present experiments terminated in 1927, and during the next few years attention will be devoted to the composition of the beds, starting with the effect of mechanical condition.

The red spider investigations have been continued and extended by the appointment of Mr. W. H. Read, who will deal with the chemical side of the problem, and Mr. O. B. Orchard, who is investigating the pest on commercial nurseries. A good deal of important information has been obtained.

Mr. Speyer is working upon the cultivation and distribution of the white fly parasite, *Encarsia formosa*, in addition to the general entomological problems and red spider investigations. A new house has been erected for the purpose and

a good stock of the parasite will be ready shortly, for distribution. Numbers of parasites were distributed last season with promising results.

Among the diseases studied during the year are *Alternaria* wilt of the carnation and a bacterial disease of the chrysanthemum. A systematic study of tomato mildew is being made, and some important facts about the effect of temperature and humidity have been obtained.

Work upon the " Maturation period " or number of days between the opening of the flower and the picking of tomato fruits as a guide to the general well-being of the plant has been continued, and previous results have been confirmed.

Experiments on the fertilising effect of carbon dioxide on glasshouse plants have been continued. A stove, burning patent fuel, which burns almost completely to carbon dioxide, has been tested again this year, and an increase of some 15 per cent. has been obtained. In 1926, the increase was about 25 per cent.

Analyses have been made of the foliage of tomato plants in soils receiving nitrogen, potash, and phosphates respectively. From the data obtained from 1924 to 1927, it is clear that the effect of omitting one nutrient is not confined to the concentration of that nutrient in the foliage. There is an interdependence between the phosphates added to the soil and the potash found in the foliage and also between the potash added to the soil and the phosphoric acid in the foliage. Where phosphates are omitted from the manures the concentration of potash in the foliage is reduced. The potash in the foliage increases with the addition of phosphates to the soil. The foliage of plants growing in soil to which no potash is added shows a high phosphoric acid content. When potash is added the phosphoric acid concentration in the foliage falls.

During the first half of 1927 the amount of nitrate nitrogen in some of the experimental plots was determined. In all the plots examined there was an accumulation of nitrates during the fallow winter months ; the concentration was not affected

by planting. The leaching which follows the first watering causes a decided fall in the nitrate content of all the plots. The omission of phosphates or potash from the manures does not appear to have any effect on the nitrate concentration.

Severe injury to the tomato crop on one nursery has been traced to the presence of chlorates in the soil. Assuming that they are the salts of sodium or potassium the concentration is probably less than 0·05 per cent. in the soil.

# DIRECTOR'S REPORT.

## 1. Experimental Results of 1927.

The practice of grading the tomato fruits from the experimental plots, adopted in 1921, was continued during the present season. The fruits are collected from each plot in numbered baskets, and graded into seven grades as follows :—

A.—" Pinks " number 5 to 7 and " Pink and Whites " 8 to 10 to the lb. These are the best quality of fruit in size, shape and colour ; " Pinks " being slightly larger than " Pink and Whites."

B.—" Whites." These are fruit of good colour, but smaller than " Pink and Whites."

C.—" Blues." This grade consists of fruit of good colour, but larger and more irregular in shape than Grade A.

D.—" Roughs." Small mis-shapen fruits about the size of cherries.

E.—Blotchy fruits which ripen irregularly.

F.—Fruits showing Blossom End Rot.

G.—Fruits showing the lesions of " Stripe Disease."

### A. Manurial Experiments with Tomatoes.

#### (a) Series G. Stable Manure Experiment.

Tomato house 1 received no stable manure during 1924 and 1925, and it seemed a suitable place in which to test the effect of varying amounts of this manure as a base dressing for tomatoes. Consequently, in 1926, the house was divided into eight equal plots. These were treated in duplicate, the pairs receiving stable manure at the rate of 15, 30, 60 and 90 tons per acre respectively. The entire house also received the usual base and top-dressing fertilisers. The results were somewhat surprising for no difference in vegetative growth was observed between the different plots, neither was there any significant difference in crop. It was thought that this might be due to the abnormal season in 1926, and the experiment was repeated with slight variation in 1927, using Ailsa Craig.

Plots G1 and G6, which received 15 tons per acre in 1926, were given the same dressing in 1927 ; plots G2 and G5 receiving 30 tons per acre in 1926, were given another 30 tons per acre in 1927, while plots G4 and G7, which received 60 tons per acre, and G3 and G8 90 tons per acre in 1926, were given no stable manure in 1927.

As in 1926, no difference in vegetative growth could be observed between the plots, and as can be seen from Table 1, no gain was obtained by increasing the dressing of stable manure beyond 15 tons per acre. Further, the residues left by the dressings of 60 tons and 90 tons per acre respectively in 1926 did not increase the yield over that produced by the residue from 30 tons per acre in 1926, augmented by a further similar dressing in 1927.

This house has been continuously cropped with tomatoes for thirteen years. The root action is poor and premature decay begins about the month of August. It seems reasonable to assume that this faulty root action is responsible for the lack of response to increased dressings of stable manure, and that under the prevailing conditions a base dressing of 15 tons of stable manure per acre is adequate. The house in question is similar to a large proportion of the tomato houses in the country, and, while the results of an experiment on one type of soil are not always applicable to other soils, the evidence is so striking that it should cause nurserymen to wonder if they are not using more stable manure than is necessary.

The experiment will have been fully justified if it will lead nurserymen to experiment along similar lines, on their own nurseries. No doubt some will find that reasonably heavy dressings are necessary under their special conditions, but it will be surprising if a large percentage of growers do not convince themselves that a relatively small dressing of stable manure is adequate for their land.

On the other hand, where the soil has come under cultivation recently, the root systems should be vigorous, and a reaction to dressings of 30 and 40 tons per acre might be expected.

**(b) Series H. Watering Experiment.**

This experiment commenced in 1926 was designed to ascertain (1) if the earliness of the crop is affected by the time of applying the first real watering, " ball watering " in the early stages being disregarded, and (2) if heavier crops can be obtained by increasing the quantity of water given at each watering. The water was applied through a 1 in. hose, which delivered 25 gallons of water per minute. In normal watering the hose was used for 8 minutes per plot during the early part of the season, the quantity of water applied being at the rate of 29,000 gallons per acre.

## Table 1.

**The Effect of Various Base-Dressings of Stable Manure.** **Variety: Ailsa Craig.**

| Plot. | 1926. | | | 1927. | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Rate of applying Stable Manure. | Tons per Acre. | Average tons per Acre. | Rate of applying Stable Manure. | Grade of Fruit: Percentage. | | | | | | | TOTAL. | | |
| | | | | | A. | B. | C. | D. | E. | F. | G. | Lbs. per Plant | Tons per Acre. | Average tons per Acre. |
| G1 | 15 tons per acre ... | 39·52 | 36·25 | 15 tons per acre ... | 85·77 | 10·99 | 0·49 | 1·20 | 0·27 | 0·27 | 1·01 | 5·82 | 44·23 | 42·44 |
| G6 | 15 „ ... | 32·98 | | 15 „ ... | 83·20 | 14·20 | — | 1·30 | — | 0·19 | 1·11 | 5·35 | 40·66 | |
| G2 | 30 tons per acre ... | 34·58 | 33·33 | 30 tons per acre ... | 83·32 | 14·54 | — | 1·27 | — | 0·22 | 0·65 | 4·74 | 36·03 | 36·18 |
| G5 | 30 „ ... | 32·07 | | 30 „ ... | 79·71 | 16·74 | 0·22 | 1·67 | — | 0·22 | 1·46 | 4·78 | 36·33 | |
| G4 | 60 tons per acre ... | 31·76 | 32·18 | None ... ... | 80·83 | 14·43 | — | 2·62 | — | — | 2·12 | 4·23 | 32·15 | 34·04 |
| G7 | 60 „ ... | 32·60 | | „ ... ... | 83·14 | 14·77 | — | 1·27 | — | — | 0·82 | 4·74 | 36·02 | |
| G3 | 90 tons per acre ... | 31·23 | 32·91 | None ... ... | 82·26 | 15·40 | — | 1·67 | — | — | 0·67 | 4·80 | 36·28 | 39·75 |
| G8 | 90 „ ... | 34·58 | | „ ... ... | 85·56 | 11·56 | 0·19 | 1·06 | 0·19 | 0·19 | 1·25 | 5·53 | 43·02 | |

## Table 2.

**The Effect of Increased Amount of Water.** **Variety: E.S. 1.**

| Plot. | 1926. Treatment. | 1926. Tons per Acre. | 1926. Average tons per Acre. | 1927. Treatment. | 1927. Grade of Fruit: Percentage. A. | B. | C. | D. | E. | F. | G. | 1927. Lbs. per Plant. | 1927. Tons per Acre. | 1927. Average tons per Acre. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Normal watering begun 10 days earlier than other plots | 34·50 | 33·82 | Normal watering 7 days earlier than other plots | 84·01 | 13·31 | 0·18 | 1·00 | 0·66 | — | 0·84 | 5·93 | 45·06 | 46·66 |
| 6 | | 33·14 | | | 86·46 | 11·33 | 0·16 | 1·42 | 0·47 | 0·16 | — | 6·35 | 48·26 | |
| 2 | Normal watering | 31·99 | 32·94 | Normal watering | 85·00 | 12·76 | 0·17 | 1·59 | 0·48 | — | — | 6·27 | 47·66 | 47·99 |
| 5 | ,, ,, | 33·89 | | ,, ,, | 86·01 | 11·49 | 0·31 | 1·72 | 0·31 | — | 0·16 | 6·36 | 48·33 | |
| 4 | 50% more water than normal | 33·75 | 31·58 | 50% more water than normal | 83·50 | 15·00 | — | 1·05 | 0·30 | — | 0·15 | 6·60 | 50·15 | 50·49 |
| 7 | | 29·41 | | | 86·20 | 12·08 | — | 1·13 | 0·29 | 0·15 | 0·15 | 6·69 | 50·84 | |
| 3 | 100% more water than normal | 34·12 | 32·91 | 100% more water than normal | 84·14 | 13·24 | 0·18 | 1·29 | 0·97 | — | 0·18 | 6·12 | 46·51 | 48·64 |
| 8 | | 31·69 | | | 85·79 | 11·98 | 0·45 | 1·04 | 0·30 | 0·15 | 0·30 | 6·68 | 50·77 | |

In plots 1 and 6, the first watering was applied just before the opening of the third truss. Ten days later, when the rest of the house was watered most of the flowers on the third truss had set and the fourth truss was opening. In 1926, no appreciable difference was observed between the crops submitted to the different treatments, but actually fruit was picked six days earlier from the first watered plots than from the remainder of the house.

For 1927, the soil in this house was sterilised by means of steam, using the harrow system, and, as might be expected, the crop was increased from 32·81 tons per acre in 1926 to 48·42 tons per acre in 1927.

It was intended to repeat the experiments of the previous season, but unfortunately the weather conditions about the time the third truss was opening suddenly became so hot and bright that it was necessary to water the entire house, and therefore the first plots, 1 and 6, were watered only seven days earlier than the rest of the house. As might be expected, the hastened ripening from these plots observed in 1926 was not so marked in 1927.

As can be seen from Table 2, the increase in quantity of water given from normal to 50 per cent. and 100 per cent. more shewed results slightly in favour of the heavier applications, whereas, in 1926, no effect was noticeable. This is no doubt due to the fact that steaming the soil so improved root development that the plants were able to make use of the additional water supplied.

The experiment has been valuable in so far as it confirms the idea that the first essential of a successful crop is the development of a luxuriant root system, and that, failing this, the application of increased waterings is no advantage.

The experiment has also been instructive in pointing the direction which future investigation should follow, because observation during its course has indicated that, while the quantity of water supplied is of importance, the method of watering is still more so. Present methods are wasteful, because so much of the water applied merely runs through the soil and does not stay long enough to produce that uniformity of soil moisture which is so important for healthy plant growth. An experiment has been devised for 1928 in which the merits of different methods of watering will be compared. The conclusions, deduced from the past watering experiments, are that under normal conditions watering should commence after the second truss has set, and the quantity should be regulated by the condition of the plant roots. It is suggested that plants with vigorous roots in well-drained soil should be given some 40,000 gallons of water per acre per week during April and May, and twice that amount during June to September. It must, however, be remembered that watering

is one of the most important tasks connected with nursery work, and that while experiments may explain to the fundamental features of this work, they can never convert it into a rule of thumb method, because so much must depend upon the condition of the plant and the nature of its environment. The present experiments will succeed if they lead to a reliable method of watering which will insure uniformity of soil moisture.

**(c) Series J and K.**

These experiments were designed to determine the correct proportions of nitrogenous, phosphatic and potassic fertilisers in a satisfactory tomato mixture. The results from series J are summarised in Table 3.

These experiments have been considered so much in previous reports that there is no need to discuss the actual details, which can be obtained from the Table on page 20. It may be more helpful to growers to emphasise the chief features.

Observation and previous experiments have suggested that the tomato crop requires a good deal of potash in the early stages to mature the tissues and hold back the plant until the fruit has developed sufficiently to retard the rate of vegetative growth. Further, as the plant becomes older it appears to require less potash and a good deal more nitrogen. An attempt was made to prove the truth of this assumption by sub-dividing plot 1 into four plots a—d. Plot 1a received two top dressings of sulphate of potash after the second truss had set ; then two dressings of a fertiliser $7\frac{1}{2} : 5 : 10$; two dressings of dried blood commencing seven days before stopping, and then the mixture and dried blood alternately. The dried blood was omitted from plot 1b, and the sulphate of potash from 1c, while 1d received the top dressing mixture only. So far as crop yield was concerned, there was little difference between the plots, but the increased vigour of the plants in plot 1a was very marked.

Plot 2 provides data concerning the persistence of stable manure residue, in the soil. In 1925, plot 2b received 14 lbs. stable manure per square yard, and there was a corresponding increase in yield. No more manure was applied in 1926, but the yield was equal to that produced by 28 lbs. stable manure per square yard on a neighbouring plot, 2c. In 1927, however, the yield has fallen to that of plot 2a, which has been unmanured for ten years. Thus while the effect of a dressing of stable manure was seen in the first two years after application to starved soil, it had disappeared in the third year.

The plots from which phosphates (J6a), nitrogen (J7a), and potash (J8a) have been omitted confirm previous findings that a deficiency of potash or nitrogen increase the amount of blotchy

**Table 3. Variety.—"Manx Marvel."**

| Plot No. | Treatment. | Lbs. per Plant. | | | | | | | | Tons per Acre. | Percent. Blotchy Fruit. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | A. | B. | C. | D. | E. | F. | G. | Total. | | |
| J1a | *See* Footnote ... ... ... ... ... | 3·44 | 0·48 | 0·24 | 0·02 | 0·03 | — | — | 4·21 | 31·99 | 0·72 |
| J1b | As 1a, but dried blood replaced by top dressing mixture ... ... ... ... ... | 2·94 | 0·58 | 0·17 | — | 0·04 | 0·01 | — | 3·74 | 28·42 | 0·77 |
| J1c | As 1a, but two dressings of sulphate of potash omitted ... ... ... ... ... | 3·12 | 0·62 | 0·14 | 0·01 | 0·03 | — | — | 3·92 | 29·79 | 1·08 |
| J1d | Top dressing mixture throughout whole season | 3·04 | 0·74 | 0·14 | — | 0·04 | — | — | 3·96 | 30·09 | 0·97 |
| J2a | Unmanured ... ... ... ... ... | 2·02 | 0·47 | 0·48 | — | 0·73 | — | — | 3·70 | 28·12 | 19·73 |
| J2b | 14 lb. stable manure pr. sq. yd., 1925, none since | 0·91 | 0·36 | 0·64 | 0·01 | 1·08 | 0·01 | — | 3·01 | 22·87 | 35·89 |
| J2c | 28 lb. stable manure per sq. yd. ... ... | 1·24 | 0·40 | 0·36 | 0·01 | 1·01 | 0·02 | — | 3·04 | 23·10 | 33·21 |
| J3a | Sulphate of potash only ... ... ... | 3·42 | 0·55 | 0·60 | — | 0·10 | — | — | 4·67 | 35·49 | 2·41 |
| J3b | 2½% nitrogen and 10% potash ... ... | 3·36 | 0·59 | 0·26 | — | 0·03 | — | 0·01 | 4·25 | 32·30 | 0·71 |
| J3c | 5% nitrogen and 10% potash ... ... ... | 2·19 | 0·57 | 0·29 | — | 0·04 | — | 0·01 | 3·10 | 23·56 | 1·27 |
| J3d | 7½% nitrogen and 10% potash ... ... | 3·50 | 0·53 | 0·21 | — | 0·07 | — | 0·01 | 4·33 | 32·90 | 1·61 |
| J4a | 5% phosphate and 10% potash ... ... | 3·21 | 0·63 | 0·88 | 0·02 | 0·10 | — | 0·01 | 4·85 | 36·86 | 2·06 |
| J4b | 7½% nitrogen, 5% phosphate and 10% potash | 3·31 | 0·51 | 0·28 | 0·01 | 0·02 | — | — | 4·13 | 31·38 | 0·47 |
| J4c | 5% nitrogen, 5% phosphate and 10% potash | 3·58 | 0·64 | 0·26 | 0·01 | 0·02 | — | — | 4·51 | 34·27 | 0·43 |
| J4d | 7½% nitrogen, 5% phosphate and 10% potash | 3·65 | 0·50 | 0·44 | — | 0·01 | — | — | 4·60 | 34·96 | 0·23 |
| J5a | Complete artificials (Formula II) ... ... | 3·12 | 0·60 | 0·28 | 0·01 | 0·06 | — | — | 4·07 | 30·93 | 1·46 |
| J5b | Complete artificials with grass ... ... ... | 2·98 | 0·58 | 0·23 | 0·04 | 0·09 | — | — | 3·92 | 29·79 | 2·28 |
| J6a | Complete artificials without phosphates ... | 3·26 | 0·58 | 0·19 | 0·01 | 0·02 | — | — | 4·06 | 30·85 | 0·49 |
| J6b | 8% phosphates ... ... ... ... ... | 3·60 | 0·58 | 0·17 | 0·01 | 0·03 | — | — | 4·39 | 33·36 | 0·69 |
| J6c | 16% phosphates ... ... ... ... ... | 2·96 | 0·66 | 0·23 | — | 0·07 | — | — | 3·92 | 29·79 | 1·78 |
| J6d | 24% phosphates ... ... ... ... ... | 3·66 | 0·63 | 0·20 | 0·01 | 0·08 | — | — | 4·58 | 34·81 | 1·75 |
| J7a | Complete artificials without nitrogen ... | 2·27 | 0·42 | 0·48 | 0·01 | 0·25 | 0·01 | — | 3·44 | 26·14 | 7·26 |
| J7b | 5% nitrogen ... ... ... ... ... | 3·29 | 0·62 | 0·34 | 0·01 | 0·20 | — | — | 4·46 | 33·89 | 4·48 |
| J7c | 7½% nitrogen ... ... ... ... ... | 3·13 | 0·52 | 0·20 | — | 0·06 | — | — | 3·91 | 29·71 | 1·52 |
| J7d | 10% nitrogen ... ... ... ... ... | 3·34 | 0·66 | 0·27 | — | 0·06 | — | — | 4·33 | 32·91 | 1·39 |
| J8a | Complete artificials without potash ... ... | 1·45 | 0·44 | 0·16 | 0·01 | 1·26 | 0·01 | — | 3·33 | 25·31 | 37·81 |
| J8b | 7½% potash ... ... ... ... ... | 3·05 | 0·56 | 0·36 | 0·02 | 0·24 | 0·01 | 0·02 | 4·26 | 32·37 | 5·62 |
| J8c | 10% potash ... ... ... ... ... | 3·42 | 0·60 | 0·18 | 0·01 | 0·10 | — | — | 4·31 | 32·75 | 2·32 |
| J8d | 12½% potash ... ... ... ... ... | 3·74 | 0·66 | 0·23 | 0·01 | 0·03 | — | — | 4·67 | 35·49 | 0·65 |

Base.—7 lb. stable manure, ¾ lb. sulphate of potash, per sq. yd. Top.—(*a*) 2 oz. sulphate of potash per sq. yd. with first watering, and 14 days later. (*b*) Followed by 2 oz. per sq. yd. of a 7½ : 5 : 10 mixture until 7 days before stopping. (*c*) 7 days before stopping, 1 oz. dried blood per sq. yd. 14 days later 2 oz. dried blood per sq. yd. Afterwards top dressing mixture and dried blood alternately.

fruit, which can be reduced to a minimum by adequate dressings of these fertilisers. The importance of these fertilisers and the comparative unimportance of phosphates for tomatoes is indicated again. Further proof is provided that the quantity of nitrogen and potash demanded by a tomato plant is affected by the weather conditions. The season 1927 was generally sunless, and as might be expected there has been a greater response to potash and less to nitrogen than during 1926.

The experiments on plots 3a-d and 4a-d have been disappointing during both 1926 and 1927. Here an attempt was made to use the information concerning nitrogen, phosphate and potash requirements obtained from plots 6, 7 and 8 by combining them in definite proportions, with the object of determining the correct proportion of these fertilisers to use in a good tomato mixture. In view of the absence of any marked difference in the crops from the various plots, it seems certain that some other factor, more important than manures, is actually masking their effect. The nature of this influence is suggested by examination of the roots, which are far from vigorous and resemble those from commercial nurseries where tomatoes are grown continuously. It seems safe to assume that the full effect of manures can only be obtained when the root action is at its maximum development.

Arrangements are being made to sterilise the soil by steam prior to next year's experiments.

Series K received the same treatment as in 1926, and the results are shewn in Table 4.

The effect of adding grass to the north half of each plot has been tried during the past two years. A marked improvement was noticed in the case of the unmanured plot, that receiving standard with complete artificials and those from which nitrogen and potash have been withheld.

**(d) Series M. Variety Trials.**

The purpose of these trials is to test newer varieties against those of established commercial excellence. The varieties tested this year include a number which were employed when tomatoes were first grown in this country, such as Chemin Rouge, Trophy, Up-to-date, and Sterling Castle. Three American varieties, Livingstone's Stone, Norduke and Ponderosa were also included.

The results are shewn in Table 5.

**Table 4.** **Variety.—"Water Baby."**

| Plot No. | Treatment. | Lbs. per Plant. | | | | | | | Total. | Tons per Acre. | Percent. Blotchy Fruit. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | A. | B. | C. | D. | E. | F. | G. | | | |
| K1b | Twice complete artificials (Formula 1) ... | 2·98 | 0·51 | 1·07 | 0·04 | 0·02 | 0·02 | — | 4·64 | 35·26 | 0·47 |
| K1a | Twice complete artificials with grass ... ... | 2·84 | 0·46 | 1·22 | 0·04 | 0·05 | 0·01 | — | 4·62 | 35·11 | 1·08 |
| K2b | Unmanured ... ... ... ... ... | 1·08 | 0·26 | 0·85 | 0·02 | 0·94 | 0·02 | 0·03 | 3·20 | 24·31 | 29·38 |
| K2a | Grass only ... ... ... ... ... | 2·22 | 0·37 | 1·12 | 0·03 | 0·45 | 0·02 | 0·01 | 4·22 | 32·07 | 10·67 |
| K3b | Standard with complete artificials ... ... | 3·01 | 0·55 | 0·93 | 0·06 | 0·03 | — | — | 4·58 | 34·81 | 1·39 |
| K3a | Standard with complete artificials with grass | 3·11 | 0·61 | 1·21 | 0·05 | 0·14 | 0·02 | — | 5·14 | 39·05 | 2·67 |
| K4b | Complete artificials with dung ... ... ... | 2·80 | 0·51 | 0·91 | 0·04 | 0·02 | 0·01 | — | 4·29 | 32·60 | 0·46 |
| K4a | Complete artificials with dung and grass ... | 2·68 | 0·54 | 0·88 | 0·03 | 0·05 | 0·01 | 0·07 | 4·26 | 32·38 | 1·27 |
| K5b | Complete artificials ... ... ... ... | 3·13 | 0·38 | 0·99 | 0·03 | 0·02 | 0·01 | 0·01 | 4·57 | 34·74 | 0·43 |
| K5a | Complete artificials with grass ... ... ... | 2·93 | 0·52 | 0·86 | 0·04 | 0·03 | 0·01 | 0·02 | 4·41 | 33·52 | 0·69 |
| K6b | Complete artificials without phosphates ... | 2·86 | 0·52 | 1·01 | 0·01 | 0·05 | 0·02 | 0·02 | 4·49 | 34·12 | 1·11 |
| K6a | Complete artificials without phosphate with grass | 2·73 | 0·52 | 0·95 | 0·05 | 0·03 | 0·01 | 0·02 | 4·31 | 32·76 | 0·66 |
| K7b | Complete artificials without nitrogen ... | 2·24 | 0·43 | 1·10 | 0·02 | 0·21 | — | 0·01 | 4·01 | 30·47 | 5·23 |
| K7a | Complete artificials without nitrogen with grass | 2·94 | 0·37 | 1·03 | 0·04 | 0·09 | 0·02 | 0·01 | 4·50 | 34·19 | 1·98 |
| K8b | Complete artificials without potash ... ... | 1·55 | 0·30 | 0·98 | 0·02 | 0·41 | 0·11 | 0·04 | 3·41 | 25·92 | 12·03 |
| K8a | Complete artificials without potash with grass | 2·27 | 0·30 | 1·07 | 0·04 | 0·33 | 0·06 | 0·11 | 4·18 | 31·76 | 7·91 |

**Table 5.**

| Variety. | Pounds per Plant. | | | | | | | | Tons per Acre. | Per cent Blotchy Ripening. |
|---|---|---|---|---|---|---|---|---|---|---|
| | A. | B. | C. | D. | E. | F. | G. | Total. | | |
| E.S. 1 ... ... | 4·09 | ·79 | ·19 | ·02 | ·01 | ·01 | — | 5·11 | 38·84 | ·19 |
| E.S. 1 x Comet ... | 4·22 | ·56 | ·28 | ·01 | — | ·01 | — | 5·08 | 38·61 | — |
| Manx Marvel ... | 3·86 | ·86 | ·30 | ·01 | ·01 | ·01 | ·01 | 5·06 | 38·46 | ·20 |
| Water Baby ... | 2·58 | ·56 | 1·42 | ·04 | ·04 | ·01 | ·01 | 4·66 | 35·42 | 1·13 |
| Ailsa Craig ... | 3·29 | 1·17 | ·15 | — | — | — | ·01 | 4·62 | 35·11 | — |
| Riverside Favo'rite | 2·85 | ·45 | 1·23 | ·02 | ·02 | ·01 | ·01 | 4·59 | 34·88 | ·45 |
| Ponderosa ... | ·35 | ·12 | 3·73 | ·02 | — | ·01 | — | 4·23 | 32·15 | — |
| Up-to-date ... | ·79 | ·38 | 2·78 | ·04 | ·09 | ·06 | ·04 | 4·18 | 31·77 | 2·15 |
| Livingst'ne'sStone | 2·75 | 1·01 | ·25 | ·01 | — | ·02 | — | 4·04 | 30·70 | — |
| Chemin Rouge ... | ·93 | ·16 | 2·62 | ·02 | ·06 | ·09 | ·02 | 3·90 | 29·64 | 1·54 |
| Trophy ... ... | ·78 | ·15 | 2·87 | ·01 | ·02 | ·04 | ·02 | 3·89 | 29·56 | ·51 |
| Comet ... ... | ·91 | ·41 | 2·11 | ·01 | ·09 | ·14 | — | 3·67 | 27·89 | 2·45 |
| Sterling Castle ... | ·99 | ·35 | 2·07 | ·02 | ·07 | ·14 | ·01 | 3·65 | 27·74 | 2·41 |
| Sunrise ... ... | ·31 | ·06 | 2·78 | ·01 | ·02 | ·02 | ·01 | 3·21 | 24·40 | ·62 |
| Mikado ... ... | ·60 | ·62 | 1·75 | ·02 | ·04 | ·08 | ·01 | 3·12 | 23·71 | 1·28 |
| Norduke ... ... | ·24 | ·06 | 1·87 | ·02 | ·01 | ·03 | ·01 | 2·24 | 17·03 | ·44 |

The variety E.S.1 raised by the Station in 1925 heads the list with 38·8 tons per acre, and is followed by the F.1 generation of a cross between E.S.1 and Comet with 38·6 tons per acre. Manx Marvel gave 38·4 tons per acre, while Ailsa Craig and Water Baby turned 35 tons per acre.

Sterling Castle and Up-to-date were reported in the twelfth Annual Report as being resistant to *Cladosporium fulvum* in the pot stage. Their inclusion in the variety trials confirmed this, for while neighbouring plants of susceptible varieties were badly attacked by mildew these two varieties remained green through the entire season. They are not immune from attack, but the symptoms are confined to yellow spots and blotches on the foliage, spore production being slight. Unfortunately they cropped badly, the fruit being on the small side. They have been crossed with E.S.1 in an attempt to raise a good variety resistant to mildew.

None of the varieties shewed marked resistance to the red spider mite. Ponderosa and Norduke are coarse growing varieties producing large ugly fruit.

Mikado possesses a curious type of rank foliage, reminiscent of the potato. The fruit is smooth, with a thick skin.

The results confirm those of previous years in shewing that the Ailsa Craig varieties are most suitable for the Station soil.

**(e) Investigations concerning the reduction in yield of the tomato crop by continuous cultivation on the same soil.**

These experiments were commenced in 1923, in four new tomato houses, three of which (N., O. and P.) were manured in the usual way, while Q received no manures at all. An average of 55·8 tons per acre were obtained from house N ; 55·2 tons per acre from O ; 51 tons per acre from P and 32·3 tons per acre from Q. In 1927, the average yield from N, O and P, taking into consideration only those plots receiving standard manurial treatment was 46·63, 41·77 and 42·11 tons per acre respectively, which is a decrease of 9·17, 13·43 and 8·87 tons per acre respectively. The difference in crop between houses N and P in 1927, 4·52 tons per acre, is practically identical with that of 4·8 tons per acre in 1923, while house O has decreased out of all proportion to the other two.

The experiments have been designed with the object of discovering some method of soil treatment which will either maintain the initial yield through a period of years, or which when applied to a poor plot will increase the yield to the first year's standard. So far, the best results have been obtained by the application of fresh grass cuttings when O3a was raised from 48·03 tons per acre in 1924 to 56·46 tons per acre in 1925, the initial yield from this plot being 57·38 tons per acre.

The application of straw in 1926, P5, gave a yield of 46·96 tons per acre, as against 42·56 tons per acre in 1925, and an initial yield of 57·68 tons per acre.

Such results suggested that the decrease in yield during succeeding years was caused by loss of green residues and fibre, the first of which is considered to stimulate bacterial activity in the soil, and the second to provide suitable conditions for soil aeration.

As beneficial results had been obtained by digging fresh grass cuttings into the soil in January, when it is difficult to secure an abundance of such material for nursery work, an attempt was made to grow a green manure crop, sown in October and turned in during January.

Houses N, O and P were divided into eight equal plots each, and half of each plot was sown with different seeds, using mustard, rape, red clover, blue lupins, winter tares, lucerne, buckwheat, and a mixture of horse beans and barley.

The seeds were sown on October 14th, and by January only mustard and rape had made reasonable growth. As can be seen from the results given in Table 6, the green manuring trials were without effect, and it would appear that the materials used are not so suitable as grass cuttings.

The top dressing fertiliser was applied in the usual way to houses O and P, but in the case of N it was intimately mixed with sixteen times its bulk of dry baked soil in November under cover. After mixing, the heap was watered and kept uniformly moist. Equivalent amounts of this mixture were applied to N whenever O and P were top-dressed with the raw fertiliser. The results obtained are in favour of mixing the fertiliser with soil in this way, because the 1927 crop from house N is much greater than that obtained in 1926. In house O the difference between the crops of the two years is not so marked, while in P the 1927 crop is lower than that for 1926.

An experiment was commenced during the present season, whereby the soil temperature of four plots was raised by electrically heated wires buried some fifteen inches below the surface. Plot P8 was maintained around 65°F. ; plot P1 at 70°F. ; O8 at 75°F., and O1 at 80°F. No significant increase in crop was obtained by heating the soil, but there was a very distinct increase in vegetative growth proportional to the increase in soil temperature. It was hoped that the increase of soil temperature would give earlier ripening, but the absence of this may be due in part to the fact that the wire was not in position sufficiently early to heat the soil some time before planting.

In house Q, previously unmanured, an attempt was made to ascertain the effect of sulphate of ammonia, superphosphate, and sulphate of potash, both singly and combined. The results are instructive when a comparison is made between the 1926 and 1927 crops. It will be seen that sulphate of potash alone increased the yield over that of 1926, while superphosphate and sulphate of ammonia used alone gave a lower yield. Used in pairs or as a complete fertiliser they increased the yield some 50 per cent.

Perhaps the most important result is that obtained from a base dressing of straw and lime, followed by a top dressing of nitrate of potash, sulphate of ammonia, and superphosphate, when the crop was raised from 20·89 tons per acre in 1926 to 37·62 tons per acre in 1927, an increase of some 80 per cent. This confirms the value of straw as a base dressing, and will form the basis for future experiments in 1928.

## B. Cucumber Experiments.

The present set of experiments were commenced in 1922 for the purpose of studying the base or soil upon which the beds are placed. Observations on commercial nurseries, where cucumbers had been grown continuously for many years, had long shewn that harm results when the roots passed through the beds and penetrated the base.

## Table 6.

**Variety: "E.S.1."**

| Plot No. | Treatment. | Lbs. per Plant. | | | | | | | | Tons per Acre. | Tons per Acre, 1926. | Percent. Blotchy Ripening. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | A. | B. | C. | D. | E. | F. | G. | Total. | | | |
| N1a | Sown with Mustard ... ... ... | 5·87 | 1·02 | 0·02 | 0·05 | 0·01 | — | 0·01 | 6·98 | 53·06 | 47·28 | 0·15 |
| N1b | Without green manure ... ... ... | 5·67 | 1·07 | 0·01 | 0·02 | — | — | 0·01 | 6·78 | 51·52 | 47·28 | — |
| N2 | Without green manure ... ... ... | 5·31 | 0·72 | — | 0·03 | — | — | 0·01 | 6·07 | 46·17 | 46·35 | — |
| N3 | Without green manure ... ... ... | 5·25 | 0·84 | — | 0·07 | — | — | — | 6·16 | 46·85 | 42·71 | — |
| N6a | Sown with Rape ... ... ... ... | 4·86 | 0·73 | — | 0·05 | — | 0·01 | 0·01 | 5·66 | 43·02 | 43·32 | — |
| N6b | Without green manure ... ... ... | 4·82 | 0·81 | — | 0·06 | — | 0·01 | 0·01 | 5·71 | 43·40 | 43·32 | — |
| N7 | Without green manure ... ... ... | 4·72 | 0·80 | — | 0·06 | — | 0·02 | — | 5·60 | 42·56 | 43·31 | 0·27 |
| N8 | Without green manure ... ... ... | 5·21 | 0·84 | — | 0·06 | — | — | 0·01 | 6·12 | 46·47 | 42·89 | — |
| O1 | Without green manure ... ... ... | 4·35 | 0·91 | 0·01 | 0·03 | — | — | — | 5·30 | 40·31 | 44·31 | — |
| O2 | Without green manure ... ... ... | 4·24 | 0·86 | 0·05 | — | — | — | — | 5·15 | 39·18 | 41·64 | 0·11 |
| O3 | Without green manure ... ... ... | 4·78 | 0·81 | — | 0·04 | — | — | — | 5·63 | 42·82 | 48·03 | — |
| O4a | Sown with Mustard ... ... ... | 4·64 | 0·68 | — | 0·05 | 0·01 | — | — | 5·38 | 40·91 | 37·22 | 0·20 |
| O4b | Without green manure ... ... ... | 4·76 | 0·84 | 0·01 | 0·03 | — | — | 0·01 | 5·65 | 42·94 | 37·22 | — |
| O5 | Phosphates omitted ... ... ... | 4·90 | 0·76 | — | 0·04 | — | — | 0·01 | 5·71 | 43·35 | 34·57 | — |
| O6 | Nitrogen omitted ... ... ... | 4·89 | 0·75 | — | 0·06 | — | — | — | 5·70 | 43·35 | 42·47 | — |
| O7 | Potash omitted ... ... ... ... | 4·55 | 0·91 | — | 0·05 | — | — | — | 5·51 | 41·87 | 44·83 | — |
| O8 | Without green manure ... ... ... | 4·42 | 0·81 | — | 0·03 | — | — | 0·02 | 5·28 | 40·16 | 42·78 | — |
| P1 | Without green manure ... ... ... | 4·01 | 1·07 | — | 0·05 | — | — | — | 5·13 | 38·44 | 41·10 | — |
| P2 | Without green manure ... ... ... | 4·00 | 0·81 | — | 0·04 | — | — | — | 4·85 | 36·89 | 42·35 | 0·11 |
| P3a | Sown with Mustard ... ... ... | 4·29 | 0·69 | 0·01 | 0·09 | — | — | — | 5·08 | 38·61 | 43·08 | — |
| P3b | Without green manure ... ... ... | 4·90 | 0·82 | — | 0·07 | — | — | 0·07 | 5·86 | 44·53 | 43·08 | — |
| P4 | Without green manure ... ... ... | 4·75 | 0·75 | — | 0·05 | — | — | — | 5·55 | 42·18 | 42·02 | — |
| P5a | Sown with Rape ... ... ... ... | 4·98 | 0·77 | 0·03 | 0·04 | — | — | 0·03 | 5·85 | 44·46 | 46·96 | — |
| P5b | Without green manure ... ... ... | 4·74 | 0·83 | — | 0·05 | — | — | — | 5·62 | 42·71 | 46·96 | — |
| P6 | Without green manure ... ... ... | 5·13 | 0·79 | — | 0·03 | — | — | — | 5·95 | 45·22 | 48·71 | — |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| P7 | Without green manure ... ... ... | 4·90 | 0·87 | — | 0·05 | — | — | 0·01 | 5·83 | 44·27 | 43·46 | 0.09 |
| P8 | Without green manure ... ... ... | 4·75 | 0·89 | — | 0·06 | — | — | 0·01 | 5·71 | 43·37 | 45·21 | — |
| Q1a | Potash and Phosphates ... ... ... | 3·10 | 0·63 | — | 0·03 | 0·15 | — | 0·04 | 3·95 | 30·02 | 20·05 | 3·80 |
| Q1b | Nitrogen, phosphate, potash and mustard ... ... ... ... | 3·52 | 0·74 | — | — | 0·20 | — | 0·05 | 4·51 | 34·27 | 31·46 | 4·44 |
| Q2a | Nitrogen and potash ... ... ... | 3·04 | 0·52 | — | 0·02 | 0·44 | — | 0·05 | 4·07 | 30·93 | 20·22 | 10·82 |
| Q2b | Phosphates only ... ... ... ... | 1·93 | 0·52 | — | 0·02 | 0·68 | — | 0·03 | 3·15 | 24·17 | 26·28 | 21·39 |
| Q3a | Potash only ... ... ... ... | 2·59 | 0·53 | — | 0·05 | 0·37 | — | 0·03 | 3·57 | 27·12 | 24·01 | 10·36 |
| Q3b | Nitrogen only ... ... ... ... | 1·79 | 0·45 | — | 0·02 | 0·34 | — | 0·02 | 2·62 | 19·91 | 24·01 | 12·99 |
| Q6a | Nitrogen and phosphates ... ... | 1·68 | 0·44 | — | 0·05 | 1·64 | — | 0·05 | 3·86 | 29·33 | 20·28 | 42·48 |
| Q6b | Nitrogen, phosphates and potash ... | 2·84 | 0·69 | — | 0·01 | 0·49 | — | 0·03 | 4·06 | 30·85 | 26·06 | 12·07 |
| Q7a | Mustard only ... ... ... ... | 1·90 | 0·52 | — | 0·05 | 0·24 | — | 0·01 | 2·72 | 20·67 | 26·98 | 8·81 |
| Q7b | Straw, lime, nitrate of potash, sulphate of ammonia, superphosphates ... | 3·62 | 0·80 | 0·01 | 0·02 | 0·45 | — | 0·05 | 4·95 | 37·62 | 20·89 | 9·09 |
| Q8a | Unmanured ... ... ... ... | 1·66 | 0·52 | — | 0·03 | 0·60 | — | — | 2·81 | 21·36 | 16·72 | 21·34 |
| Q8b | Unmanured 1927. Nitrogen, phosphates and potash, 1926 ... ... | 3·21 | 0·69 | — | 0·03 | 0·51 | — | 0·02 | 4·46 | 33·89 | 37·53 | 11·42 |

## Table 7.

| Plot No. | Treatment. | Lbs. per Plant. | | | | | | | | Tons per Acre. | Flats per Foot. | Relative. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | March. | April. | May. | June. | July. | Aug. | Sept. | Total. | | | | |
| C1 | Base and old bed steamed ... | ·70 | 15·75 | 13·33 | 10·28 | 8·26 | 8·46 | 8·23 | 65·01 | 97·51 | 1·96 | 106 | 105 |
| C3 | Base and old bed steamed ... | ·33 | 16·88 | 14·68 | 10·77 | 8·43 | 7·54 | 5·99 | 64·62 | 96·93 | 1·95 | 105 | |
| C2 | Base steamed, new bed ... ... | ·48 | 17·62 | 13·05 | 11·86 | 7·68 | 6·64 | 8·40 | 65·73 | 98·59 | 1·98 | 107 | 111 |
| C4 | Base steamed, new bed ... ... | ·83 | 17·25 | 15·81 | 10·50 | 9·88 | 8·47 | 8·09 | 70·83 | 106·24 | 2·14 | 115 | |
| D2 | Base steamed, new bed ... ... | 1·00 | 16·27 | 13·15 | 12·26 | 8·01 | 7·18 | 7·15 | 65·02 | 97·53 | 1·96 | 106 | |
| D3 | Old bed steamed over concrete | ·75 | 16·48 | 12·43 | 10·47 | 8·46 | 6·80 | 5·24 | 60·63 | 90·94 | 1·83 | 99 | |
| E2 | New big bed ... ... ... | 1·46 | 14·35 | 12·43 | 9·03 | 7·66 | 6·43 | 5·64 | 57·00 | 85·50 | 1·72 | 93 | |
| E3 | Control ... ... ... ... | 1·62 | 14·97 | 14·01 | 9·45 | 9·21 | 7·41 | 4·56 | 61·23 | 91·84 | 1·85 | 100 | |
| F2 | Gravel base, unmanured ... | 1·41 | 15·56 | 12·33 | 8·85 | 6·85 | 6·11 | 4·60 | 55·71 | 83·56 | 1·68 | 91 | |
| F3 | Base flooded, manured ... ... | ·76 | 15·37 | 12·74 | 10·93 | 5·88 | 5·89 | 5·62 | 57·19 | 85·78 | 1·72 | 93 | |
| F4 | Base steamed, manured ... | 1·04 | 17·30 | 13·13 | 9·51 | 6·16 | 6·41 | 7·75 | 61·30 | 91·95 | 1·85 | 100 | |
| F5 | Base steamed, unmanured ... | ·72 | 16·71 | 14·11 | 11·44 | 9·29 | 7·53 | 5·16 | 64·96 | 97·44 | 1·96 | 106 | |
| B1 | Watered with drainage from steamed old bed ... ... | ·77 | 19·13 | 18·37 | 13·88 | 6·39 | — | — | 58·54 | 87·81 | 1·76 | 95 | |
| B4 | Steamed old bed ... ... | — | 11·07 | 13·73 | 10·02 | 5·45 | — | — | 40·27 | 60·41 | 1·21 | 65 | |
| B2 | Watered with drainage from old bed untreated ... ... | ·83 | 14·27 | 14·16 | 11·21 | 4·27 | — | — | 44·74 | 67·11 | 1·35 | 73 | |
| B3 | Old bed, untreated ... ... | ·87 | 10·94 | 9·93 | 6·81 | 3·71 | — | — | 32·26 | 48·39 | ·99 | 52 | |
| D1 | Base steamed, new bed ... ... | ·82 | 11·92 | 8·74 | 8·40 | 6·33 | 6·40 | 5·68 | 48·29 | 72·43 | 1·46 | 79 | |
| E1 | Base steamed, new bed ... ... | 1·63 | 16·39 | 11·88 | 11·22 | 10·33 | 7·24 | 7·92 | 66·61 | 99·91 | 2·01 | 108 | |
| F6 | Base steamed, new bed, laid on a core of hedge clippings ... | 1·02 | 17·86 | 14·06 | 10·61 | 10·15 | 8·69 | 8·19 | 70·58 | 105·87 | 2·13 | 115 | |
| D4 | Base steamed, new bed with ashes added ... ... ... | 1·08 | 14·30 | 12·06 | 12·07 | 9·94 | 7·80 | 7·14 | 64·39 | 96·58 | 1·94 | 104 | |
| E4 | Base steamed, new bed with ashes added ... ... ... | 1·58 | 16·97 | 13·58 | 12·24 | 11·39 | 7·99 | 7·65 | 71·40 | 107·10 | 2·16 | 117 | |
| F1 | Base steamed, new bed with ashes added ... ... ... | 1·52 | 16·39 | 12·23 | 11·84 | 8·63 | 8·13 | 6·84 | 65·58 | 98·37 | 1·98 | 107 | |

The experiments of 1927, shewn in Table 7, have in the main confirmed past results.

Steaming the base has again proved beneficial, but the effect of steaming was not enhanced by manuring the base in addition.

In 1926, house B, an attempt was made to prove that the inhibiting factor in old cucumber beds can be washed out in the drainage water. For this purpose an old bed was placed on a raised platform of corrugated asbestos sheets, from which the drainage was collected in a painted tank. The drainage was watered periodically over a steam sterilised bed on the opposite side of the house. As a control, another portion of an old bed was steamed and placed on a similar platform, with tank for collecting drainage, which was also watered over a sterilised bed on the opposite side of the house. The results suggested that inhibiting agents present in the old bed were transferred in the drainage water to the sterilised bed opposite.

The experiment was repeated in 1927, when similar results were obtained. The plot (B2) watered from the old bed, produced 1·62 flats per foot in 1926 and 1·35 flats per foot in 1927, while that (B1) watered from the steamed old bed gave 1·89 flats per foot in 1926 and 1·76 flats per foot in 1927. Such results suggest that the harmful influences produced in the beds during the season are washed down into the base and accumulate there.

It has been decided to discontinue this side of experiments in 1928, and it is now possible to give the conclusions to be drawn from six years' experiments as follows :—

(1.) When the cucumber is grown in a bed of loam and stable manure for one complete season, the bed is rendered unsuitable for cucumber cultivation during the following season.

(2.) By the continuous cultivation of the cucumber in beds placed on the same soil during a number of years, the base becomes contaminated, and is injurious to the roots of cucumbers which may penetrate it.

(3.) While the precise nature of the contamination remains unknown, it has been shewn to be washed down from the bed into the base by drainage water.

(4.) A base of heavy soil holds the contaminations better than light loam and is to be avoided if possible.

(5.) Sterilisation of a contaminated base by means of steam causes a marked improvement in crop and presumably destroys or removes the contamination. No success has attended the use of formaldehyde or cresylic acid.

(6.) The beneficial effects of steaming last one year only, and therefore it is necessary to steam old soil every year.

(7.) The improvement of the crop which results from steaming the base is affected by the weather during the early stages of growth. Favourable weather enhances the vitality of the plant, and thus enables it to take full advantage of the sterilised soil. During unfavourable weather, the plants do not make such a good start and in some cases sterilisation of the base has caused slight retardation in the early stages.

(8.) It is advisable to delay steaming the base as long as possible so as to take advantage of planting in warmed soil.

(9.) The substitution of a poor gravel soil or even washed ashes for a contaminated base causes an immediate improvement in crop, and the plants retain their vigour to the end of the season.

(10.) So long as the base of gravel or ashes remains sufficiently porous, it can be cleaned at the end of the season by removing the bed above it, and thoroughly flooding with water.

(11.) By spreading and steaming the beds at the end of the season, a higher crop is obtained under the Experimental Station conditions than by removing the old beds, steaming the base, and introducing new beds.

(12.) A crop of practically two flats per foot has been obtained over a concrete covered base, when the bed was sufficiently big, namely, the previous year's bed spread and steamed.

(13.) Increased yields have not been obtained by manuring the base, and a bad effect has followed the addition of stable manure to a steamed base.

(14.) Improved drainage by the incorporation of clinkers in the base has proved beneficial.

The experiments of 1927 suggest new lines for experiments, which will be started in future years.

These mainly concern the mechanical composition of the bed, and indicate that crop improvement follows increased aeration of the bed by the inclusion of such opening materials as ashes, clinkers and hedge clippings.

**Table 8.**

Shewing the composition of the beds and top-dressing treatment employed in the cucumber experiments.

| Plots. | Beds. | Top Dressing. | |
|---|---|---|---|
| | | First Dressing : Mar. 16th. | Remaining Dressings : Mar. 31st to Aug. 25th. |
| B3, B4, C3, C1, D3 | Beds used in 1926 with 50% stable manure added | Baked soil and stable manure with 14 lbs. bone meal to every 100 ft. of border | Baked soil and stable manure with 14 lbs. fertiliser as given in tomato series G, H and M to every 100 ft. of border |
| All other plots | Two parts baked soil and one part stable manure composted in November | As above | As above |

A special top dressing was applied to all plots on April 28th, May 17th, and July 5th. It consisted of 2 oz. per square yard of the following mixture : 2 parts sulphate of ammonia, 1 part sulphate of potash, 6 parts superphosphate and 10 parts dried blood.

# 3. Mycological Investigations.

Diseases brought to the Station and not previously reported are listed below.

| Host. | Disease. | Cause. |
|---|---|---|
| Antirrhinum ... | Leaf spot ... | ... *Heteropatella antirrhini.* |
| Arum ... ... | Soft rot ... | ... *Phytophthora richardiae.* |
| Cabbage ... ... | Leaf spot ... | ... *Mycosphaerella brassicicola.* |
| Chrysanthemum ... | Stem rot ... | ... *Bacillus sp.* |
| ,, ... | ,, ... | ... *Botrytis sp.* |
| Cucumber ... ... | Leaf spot ... | ... *Trichothecium roseum.* |
| Currant ... ... | Cane blight... | ... *Leptosphaeria coniothyrium.* |
| Cyclamen ... ... | Root rot ... | ... *Thielavia basicola.* |
| Freesia ... ... | — ... | ... Frost injury. |
| Gooseberry ... | Cane blight... | ... *Leptosphaeria coniothyrium* |
| Melon ... ... | Wilt ... | ... *Verticillium albo-atrum.* |
| ,, ... ... | Damping-off | ... *Phytophthora sp.* |
| Odontoglossum ... | Leaf spot ... | ... *Cephalosporium sp.* |
| ,, ... | ,, ... | ... *Cercospora odontoglossi.* |
| Rose ... ... | Stem rot ... | ... *Botrytis sp.* |
| Sweet Pea ... ... | Mosaic ... | ... Cause unknown. |
| Tomato ... ... | Foot rot ... | ... *Diplodina lycopersici.* |
| ,, ... ... | Fruit rot ... | ... ,, ,, |
| Violet ... ... | Rust ... | ... *Puccinia violae.* |

In addition, " foot rot " of the tomato due to *Rhizoctonia solani* which is rarely of any importance to commercial growers in this country has been reported as causing serious damage on several nurseries this year.

## 1. A Bacterial Disease of the Chrysanthemum.

P. H. Williams.

During August, 1927, a chrysanthemum disease, previously undescribed, was discovered on plants growing in the open. Attention was first attracted to it by a curious drooping of the blooms caused by a hollowness of the stalk immediately below the calyx. Systematic examination of the crop proved that in a large proportion of cases the flower stalks were affected in this manner. When the flower and stalk were cut open longitudinally, the hollow cavity was seen to be brown in colour extending over two or three inches in the stalk and passing into the capitulum.

Isolations yielded a practically pure culture of a cream bacterium which proved capable of producing the typical rot.

**The Organism.**

The original cultures were continually plated to ensure purity of the cultures. The organism is rod-shaped, 1·5$\mu$ to 2·1$\mu$ long and 0·5$\mu$ wide, the extreme variation in length being 1·2$\mu$ to 3·2$\mu$. It has rounded ends and occurs singly or in pairs, occasionally forming filaments containing up to nine or ten elements. It bears 1—3 polar flagella. No spores or capsules have been observed. When stained with carbol fuchsin, a number of deeply staining granules are present.

## CULTURAL CHARACTERS.

**Plate Cultures of Beef Extract Agar.**

"Difco Standardised" beef extract and "Difco" peptone were used in the preparation of the medium, which was neutral to Brom-thymol-blue.

After three days the colonies were somewhat irregular, 1-3m.m. in diameter, cream, smooth, shining, translucent, the centre being deeper in colour than the rest of the colony and the margin slightly undulate.

**Streak Cultures on Beef Extract Agar.**

The growth is cream yellow, smooth, shining, translucent, slightly raised, the margin entire to undulate. Some cultures are a deeper yellow than others.

**Plate Cultures on Beef Extract Gelatine.**

After two days at room temperature, the colonies are 1 m.m. to 2 m.m. in diameter, white, circular, each in a shallow liquefaction pit. Subsequently the colonies lose their identity owing to the rapid liquefaction of the medium and become dispersed in the liquid produced from the gelatine. The liquefied areas coalesce until the whole is converted into a turbid fluid with an abundant precipitate.

**Stab Cultures on Beef Extract Gelatine.**

Liquefaction has been observed at the surface of the medium within eight hours of inoculation. There is no growth in the lower portion of the stab. Liquefaction is at first infundibuliform and later, when it reaches the side of the tube, stratiform. In four weeks it extends to the depth of about 1 inch. The liquid is turbid, with pellicle and a heavy yellow precipitate.

**Beef Extract Bouillon.**

The medium becomes turbid, with a slight pellicle and precipitate.

**Dunham's Solution.**

Growth is similar to that in bouillon. At the end of four weeks there was a slight trace of indol, shown by a pink colour with concentrated sulphuric acid in the presence of a nitrite.

**1 % Peptone Water + 1 % Potassium nitrate.**

Growth is similar to that in bouillon. Nitrites were tested for at intervals for a period of four weeks, but were absent.

**10 % Peptone Water + 2 % Glucose.**

No acid is produced and the litmus is bleached. A yellow ring is formed at the surface but later disappears. The medium becomes cloudy and a slight pellicle is formed. There is no gas production.

**10 % Peptone Water + 2 % Lactose.**

Reactions similar to those in Glucose.

**10 % Peptone Water + 2 % Sucrose.**

Reactions similar to those in Glucose.

**10 % Peptone Water + 2 % Glycerine.**

Reactions similar to those in Glucose.

**Milk.**

The casein is not coagulated but slowly peptonised to form a yellow turbid fluid with no odour. There is a pellicle and a moderate precipitate.

**Litmus Milk.**

There is a slight development of alkalinity in the first few days. Later the litmus is bleached and peptonisation proceeds slowly, without curd formation. The final stage is as in milk.

**Steamed Potato Cylinder.**

The growth is yellow, wet, shining and spreading. The medium is discoloured.

**Diastatic action.**

A culture in 1% peptone water was added to an equal quantity of a thin starch paste containing 1% thymol. After incubating for 24 hours at 25°C., no sugar was found on boiling with Benedicts' solution.

**Uschinsky's Solution.**

The litmus is bleached and the liquid becomes turbid, with the formation of a slight pellicle and precipitate.

**Atmosphere.**

There is no growth in an atmosphere freed from oxygen by absorption in pyrogallol.

**Bacterial Number.**

On the basis of these reactions, the bacterial number is B. 211,3332533.

**Relations of the Organisms.**

Two organisms have been described which resemble in cultural characters the organism causing the chrysanthemum rot, namely, *Bacterium exitiosum* Gardner and Kendrick and *Bacterium vesicatorium* Doidge. Both cause a canker and leaf spot of the tomato, and the former also attacks the pepper. They are regarded as being identical by Gardner and Kendrick.

*Bacterium exitiosum* appears from the published description to resemble the chrysanthemum organism very closely, but differs in several particulars. Thus it does not stain the medium when grown on steamed potato cylinders, nor does it grow in Uschinsky's solution, but in this case the medium may not be the same as that used in the present investigation. Indol is not produced by *B. exitiosum*. However, as the chrysanthemum organism produced merely a trace after four weeks, it is possible that sufficient time was not allowed in the case of *B. exitiosum*.

The chrysanthemum organism is capable of rotting the tomato stem, but up to the present has produced no lesions on the leaf. Further experiments are, however, necessary before coming to a final conclusion on this point, since temperatures have been too low.

Cultures of these two organisms cannot be obtained in this country, and therefore direct comparison with the chrysanthemum organism has as yet been impossible. Such a comparison will be carried out as soon as the cultures can be obtained. In the meantime, the facts so far elicited are suggestive of a close relationship.

**INOCULATIONS.**

Eight varieties of chrysanthemums growing in pots out of doors at the Station were inoculated on August 26th. One shoot of each variety was inoculated in two or three places, by pricking a small portion of a culture into the stem and covering the wounds with tin foil. A corresponding number of wounds were made in a second shoot without introducing the organism, to serve as controls. The uppermost point of inoculation (A) was examined on September 20th, and the remainder (B and C) on October 13th.

In most cases a pink to red brown colour was produced in the pith and cortex and in some the wood was also affected. The extent of the lesion is shown in Table 1, the letters referring to the points of inoculation from above downwards. In two cases the pith was slightly browned around the wounds in the control plants.

**Table 1.**

Extent of browning in different varieties of Chrysanthemum.

| | A. 25 Days. | B. 48 Days. | C. 48 Days. |
|---|---|---|---|
| A. J. Balfour ... ... | At prick | 3 inches | 2 inches. |
| Baldock's Crimson ... | ½ inch | Very slight | — |
| Favourite ... ... | At prick | 2 inches | — |
| Cheshunt White (Strain 1) | ,, | 1 inch | At prick. |
| Cheshunt White (Strain 2) | ¼ inch | At prick | ,, |
| Mrs. George Monro ... | At prick | ,, | — |
| Phyllis Cooper ... ... | ,, | 2 inches | — |
| Exmouth Beauty ... | ,, | ¾ inch | 1¾ inches. |

It is probable that most varieties are susceptible to the disease, since only one of those tested, Mrs. George Monro, was practically unaffected. Re-isolations from those plants in which the lesion was of sufficient extent, were found to agree with the original culture in all respects. Subsequent inoculations with these cultures, using young lateral shoots of the variety A. J. Balfour, were again successful.

From the position of the lesion it would appear that infection takes place in the young flower and spreads thence into the stalk. Two shoots with one young bud each were therefore sprayed with a suspension of the organism in sterile water. Controls were sprayed with water. After 15 days the interior of one bud was found to be completely rotten and the brown, dead tissue extended a short distance into the stalk. The organism was re-isolated and produced a typical rot when inoculated into a chrysanthemum stem. A second bud remained healthy.

Flowers sprayed when the ray florets were just commencing to expand remained healthy.

Hypodermic injections into the flower bud, using a suspension of the bacterium, led to a complete internal rot of the flower extending a quarter of an inch into the stalk within 13 days. After one month an inoculated flower had become distorted, a few ray florets only developing while most of the disc florets aborted. The controls remained healthy and produced normal flowers.

## INOCULATIONS OF OTHER PLANTS.

### Tomato.

In stem inoculations the pith was rotted and the wood browned. In 13 days the rot had advanced as much as 3 inches along the wood.

No lesions have as yet been produced by spraying the foliage with a suspension of the organism.

### Tobacco.

When the organism was pricked into the stem, the pith was browned for a distance of 1 to 2 inches in 25 days.

### Broad Bean.

The broad bean was also found to be susceptible, lesions 1 inch long being produced in a week.

The organisms re-isolated from these plants were inoculated into the chrysanthemum and tomato and produced typical lesions. They were also found to agree with the original culture in all other respects.

### Melon.

There was a slight browning in the pith, but the organism was not re-isolated.

No infection was obtained with the cucumber, sweet pea or edible pea.

### Inoculation of Vegetables.

Various vegetables were inoculated by pricking in the organism under aseptic conditions. The results are given in Table 2.

**Table 2.**

Inoculation of Vegetables.

| | | | |
|---|---|---|---|
| Carrot ... ... | No rot. | Cabbage stalk ... | No rot. |
| Parsnip ... ... | ,, | Onion ... ... | Rot. |
| Turnip ... ... | Rot. | Celery petiole ... | Slight rot. |
| Beet ... ... | Slight rot. | Tomato fruit ... | Rot. |
| Potato ... ... | No rot. | Cucumber fruit | ,, |


### Summary.

(1.) A bacterial disease of the chrysanthemum is described in which the typical symptoms are rotting of the pith of the flower stalk immediately below the capitulum, causing the flower head to fall over.

(2.) The causal organism is a bacillus, the characters and general relationships of which are discussed.

(3.) The results of inoculation experiments with chrysanthemums and other plants and vegetables are recorded.

## 2. The Effect of Some Compounds on *Verticillium* Wilt of the Tomato.

P. H. Williams.

Investigations of "Sleepy Disease" of the tomato were described in the Sixth Annual Report, 1920. It was shown that the disease is caused by a fungus, *Verticillium albo-atrum*, and that it can be controlled by raising the temperature to an average of 77°F., shading the houses and replacing root watering by overhead damping. This treatment is entirely satisfactory when a large proportion of the plants in a block are diseased. With the decrease in the intensity of the disease in recent years, however, a need has arisen for a method of treating individual plants or small groups of plants without interfering with the normal cultivation of the remainder.

Preliminary experiments have been carried out this year with the object of finding an alternative treatment. A number of substances have been applied to the soil around diseased plants and the effect on the progress of the disease noted. The results are detailed below.

**Method.**

Young tomato plants, 6 to 8 inches high, were inoculated by pricking pieces of a culture of *Verticillium albo-atrum* into the stem just below the cotyledons. They were then potted into 6 in. pots and were treated at the end of ten to fourteen days. The substances tested were used at the rate of $\frac{1}{32}$ oz., $\frac{1}{16}$ oz., $\frac{1}{8}$ oz. per pot and the treatment was repeated three times at weekly intervals. In most cases the solid was applied and immediately watered in. Deliquescent compounds were applied in solution form, using 100 ccs. per pot. Four plants were treated at each strength and six controls were assigned to each substance.

Through lack of space in the house the experiment had to be carried out in the open. The temperature was unfavourable to the development of the disease and complete wilting did not occur on any plants. In estimating the effect of treatment on

the disease, therefore, the increase in the number of yellow and dead leaves was taken as the standard of comparison. The affected leaves were counted on the day before each treatment and for two weeks after the third. The results are shewn in Table 3.

**Table 3.**

Results of treating plants infected with "Sleepy Disease" with various substances.

| Substance. | Amt. per pot. | No. of Plants. | Temperature °F. | | | Av. No. of leaves affected before treatment. | Av. increase in No. of affected leaves. |
|---|---|---|---|---|---|---|---|
| | | | Abs. Min. | Abs. Max. | Av. | | |
| Magnesium carbonate 1 part, Lime 1 part | $\frac{1}{32}$ oz. | 4 | 43 | 85 | 61·6 | 3·0 | 4·75 |
| Ditto ... ... | $\frac{1}{16}$ oz. | 4 | 43 | 85 | 61·6 | 3·75 | 4·25 |
| Ditto ... ... | $\frac{1}{8}$ oz. | 4 | 43 | 85 | 61·6 | 4·25 | 4·25 |
| Control ... ... | — | 6 | 43 | 85 | 61·6 | 2·5 | 7·0 |
| Magnesium carbonate 2 parts, Lime 1 part | $\frac{1}{32}$ oz. | 4 | 43 | 85 | 61·6 | 3·75 | 5·75 |
| Ditto ... ... | $\frac{1}{16}$ oz. | 4 | 43 | 85 | 61·6 | 2·75 | 5·5 |
| Ditto ... ... | $\frac{1}{8}$ oz. | 4 | 43 | 85 | 61·6 | 2·5 | 6·75 |
| Control ... ... | — | 6 | 43 | 85 | 61·6 | 4·5 | 6·0 |
| Magnesium carbonate 1 part, Lime 2 parts | $\frac{1}{32}$ oz. | 4 | 43 | 85 | 61·6 | 2·75 | 6·75 |
| Ditto ... ... | $\frac{1}{16}$ oz. | 4 | 43 | 85 | 61·6 | 3·5 | 5·5 |
| Ditto ... ... | $\frac{1}{8}$ oz. | 4 | 43 | 85 | 61·6 | 0·5 | 6·25 |
| Control ... ... | — | 6 | 43 | 85 | 61·6 | 1·5 | 5·0 |
| Magnesium carbonate | $\frac{1}{32}$ oz. | 4 | 43 | 85 | 61·6 | 1·0 | 7·0 |
| Ditto ... ... | $\frac{1}{16}$ oz. | 4 | 43 | 85 | 61·6 | 0·5 | 5·5 |
| Ditto ... ... | $\frac{1}{8}$ oz. | 4 | 43 | 85 | 61·6 | 0·75 | 5·25 |
| Control ... ... | — | 6 | 43 | 85 | 61·6 | 1·0 | 6·0 |
| Magnesium sulphate | $\frac{1}{32}$ oz. | 4 | 43 | 85 | 62·7 | 2·25 | 5·0 |
| Ditto ... ... | $\frac{1}{16}$ oz. | 4 | 43 | 85 | 62·7 | 1·25 | 7·0 |
| Ditto ... ... | $\frac{1}{8}$ oz. | 4 | 43 | 85 | 62·7 | 0·5 | 7·25 |
| Control ... ... | — | 6 | 43 | 85 | 62·7 | 0 | 6·0 |
| Magnesium nitrate ... | $\frac{1}{32}$ oz. | 4 | 43 | 85 | 62·7 | 0 | 7·0 |
| Ditto ... ... | $\frac{1}{16}$ oz. | 4 | 43 | 85 | 62·7 | 0·25 | 5·25 |
| Ditto ... ... | $\frac{1}{8}$ oz. | 4 | 43 | 85 | 62·7 | 0 | 5·25 |
| Control ... ... | — | 6 | 43 | 85 | 62·7 | 0·5 | 6·5 |
| Magnesium chloride | $\frac{1}{32}$ oz. | 4 | 43 | 85 | 62·7 | 0 | 6·75 |
| Ditto ... ... | $\frac{1}{16}$ oz. | 4 | 43 | 85 | 62·7 | 0·25 | 6·5 |
| Ditto ... ... | $\frac{1}{8}$ oz. | 4 | 43 | 85 | 62·7 | 0 | 6·5 |
| Control ... ... | — | 6 | 43 | 85 | 62·7 | 0 | 7·0 |
| Lime ... ... ... | $\frac{1}{32}$ oz. | 4 | 43 | 85 | 62·7 | 0·75 | 6·25 |
| Ditto ... ... | $\frac{1}{16}$ oz. | 4 | 43 | 85 | 62·7 | 0·75 | 6·75 |
| Ditto ... ... | $\frac{1}{8}$ oz. | 4 | 43 | 85 | 62·7 | 2·0 | 5·75 |
| Control ... ... | — | 6 | 43 | 85 | 62·7 | 1·0 | 6·0 |
| Calcium carbonate ... | $\frac{1}{32}$ oz. | 4 | 43 | 85 | 62·7 | 2·0 | 6·25 |
| Ditto ... ... | $\frac{1}{16}$ oz. | 4 | 43 | 85 | 62·7 | 1·25 | 6·25 |
| Ditto ... ... | $\frac{1}{8}$ oz. | 4 | 43 | 85 | 62·7 | 1·0 | 6·0 |
| Control ... ... | — | 6 | 43 | 85 | 62·7 | 1·5 | 6·0 |
| Calcium sulphate ... | $\frac{1}{32}$ oz. | 4 | 43 | 83 | 63·2 | 1·0 | 5·25 |
| Ditto ... ... | $\frac{1}{16}$ oz. | 4 | 43 | 83 | 63·2 | 1·25 | 4·25 |
| Ditto ... ... | $\frac{1}{8}$ oz. | 4 | 43 | 83 | 63·2 | 0·5 | 5·25 |
| Control ... ... | — | 6 | 43 | 83 | 62·2 | 1·5 | 5·0 |

**Table 3** (*continued*).

| Substance. | Amt. per pot. | No. of Plants. | Temperature °F. | | | Av. No. of leaves affected before treatment. | Av. increase in No. of affected leaves. |
|---|---|---|---|---|---|---|---|
| | | | Abs. Min. | Abs. Max. | Av. | | |
| Calcium chloride ... | 1/32 oz. | 4 | 43 | 83 | 63·2 | 3·5 | 3·25 |
| Ditto ... ... | 1/16 oz. | 4 | 43 | 83 | 63·2 | 3·25 | 3·75 |
| Ditto ... ... | 1/8 oz. | 4 | 43 | 83 | 63·2 | 3·25 | 5·0 |
| Control ... ... | — | 6 | 43 | 83 | 63·2 | 2·5 | 5·0 |
| Potassium permanganate ... | 1/32 oz. | 4 | 43 | 85 | 64·9 | 4·25 | 4·0 |
| Ditto ... ... | 1/16 oz. | 4 | 43 | 85 | 64·9 | 4·0 | 3·5 |
| Ditto ... ... | 1/8 oz. | 4 | 43 | 85 | 64·9 | 3·75 | 2·5 |
| Control ... ... | — | 6 | 43 | 85 | 64·9 | 3·5 | 4·0 |
| Potassium nitrate | 1/32 oz. | 4 | 45 | 83 | 59·6 | 0 | 3·75 |
| Ditto ... ... | 1/16 oz. | 4 | 45 | 83 | 59·6 | 0 | 2·5 |
| Ditto ... ... | 1/8 oz. | 4 | 45 | 83 | 59·6 | 0 | 1·75 |
| Control ... ... | — | 6 | 45 | 83 | 59·6 | 0 | 4·0 |
| Sodium nitrate ... | 1/32 oz. | 4 | 45 | 83 | 62·9 | 0 | 6·5 |
| Ditto ... ... | 1/8 oz. | 4 | 45 | 83 | 62·9 | 0 | 5·0 |
| Control ... ... | — | 4 | 45 | 83 | 62·9 | 0 | 6·25 |
| Sodium nitrate ... | 1/16 oz. | 4 | 45 | 83 | 61·6 | 0 | 4·0 |
| Control ... ... | — | 2 | 45 | 83 | 61·6 | 0 | 5·0 |
| Ammonium sulphate | 1/32 oz. | 4 | 45 | 83 | 59·6 | 0 | 3·25 |
| Ditto ... ... | 1/16 oz. | 4 | 45 | 83 | 59·6 | 0 | 1·25 |
| Ditto ... ... | 1/8 oz. | 4 | 45 | 83 | 59·6 | 0 | 2·0 |
| Control ... ... | — | 6 | 45 | 83 | 59·6 | 0 | 4·0 |
| Ammonium carbonate | 1/32 oz. | 4 | 45 | 83 | 59·6 | 0 | 1·75 |
| Ditto ... ... | 1/16 oz. | 4 | 45 | 83 | 59·6 | 0 | 3·25 |
| Ditto ... ... | 1/8 oz. | 4 | 45 | 83 | 59·6 | 0 | 3·0 |
| Control ... ... | — | 6 | 45 | 83 | 59·6 | 0 | 3·5 |
| Ferrous sulphate ... | 1/32 oz. | 4 | 43 | 85 | 64·9 | 2·75 | 3·5 |
| Ditto ... ... | 1/16 oz. | 4 | 43 | 85 | 64·9 | 3·0 | 2·5 |
| Ditto ... ... | 1/8 oz. | 4 | 43 | 85 | 64·9 | 3·0 | 2·75 |
| Control ... ... | — | 6 | 43 | 85 | 64·9 | 2·0 | 4·5 |
| Copper sulphate ... | 1/32 oz. | 4 | 45 | 83 | 62·9 | 0 | 5·75 |
| Ditto ... ... | 1/16 oz. | 4 | 45 | 83 | 62·9 | 0 | 6·5 |
| Ditto ... ... | 1/8 oz. | 4 | 45 | 83 | 62·9 | 0 | 6·0 |
| Control ... ... | — | 6 | 45 | 83 | 62·9 | 0 | 5·5 |
| Copper silico fluoride | 1/32 oz. | 4 | 43 | 85 | 64·9 | 2·0 | 5·5 |
| Ditto ... ... | 1/16 oz. | 4 | 43 | 85 | 64·9 | 2·0 | 4·5 |
| Ditto ... ... | 1/8 oz. | 4 | 43 | 85 | 64·9 | 0·5 | 7·0 |
| Control ... ... | — | 6 | 43 | 85 | 64·9 | 1·0 | 5·5 |
| Nickel silico fluoride | 1/32 oz. | 4 | 43 | 85 | 64·9 | 0·25 | 5·5 |
| Control ... ... | — | 2 | 43 | 85 | 64·9 | 0·5 | 5·0 |
| Nickel silico fluoride | 1/16 oz. | 4 | 44 | 85 | 64·5 | 1·5 | 6·25 |
| Ditto ... ... | 1/8 oz. | 4 | 44 | 85 | 64·5 | 0·75 | 5·5 |
| Control ... ... | — | 4 | 44 | 85 | 64·5 | 1·5 | 5·75 |
| Manganese silico fluoride ... ... | 1/32 oz. | 4 | 44 | 85 | 64·5 | 3·0 | 7·0 |
| Ditto ... ... | 1/16 oz. | 4 | 44 | 85 | 64·5 | 2·0 | 5·5 |
| Ditto ... ... | 1/8 oz. | 4 | 44 | 85 | 64·5 | 1·0 | 6·75 |
| Control ... ... | — | 6 | 44 | 85 | 64·5 | 0·5 | 5·5 |
| Barium silico fluoride | 1/32 oz. | 4 | 45 | 83 | 62·9 | 0 | 6·75 |
| Ditto ... ... | 1/16 oz. | 4 | 45 | 83 | 62·9 | 0 | 7·0 |
| Ditto ... ... | 1/8 oz. | 4 | 45 | 83 | 62·9 | 0·25 | 6·0 |
| Control ... ... | — | 6 | 45 | 83 | 62·9 | 0 | 7·0 |

**Table 4.**

Cheshunt Compound has been used at the rate of ½ oz., 1 oz., and 2 oz. per gallon and Uspulun at 0·25%. 200 cc. of the solution were given to each plant at the same intervals as with other compounds.

| Substance. | Str | Temperature. | | | | Av. No. of leaves affected before treat. | Av. inc. in No. of affected leaves. |
|---|---|---|---|---|---|---|---|
| | | No. of Plants. | Abs. Min. | Abs. Max. | Av. | | |
| Cheshunt compound | ½ oz. | 4 | 45 | 83 | 59·6 | 0 | 2·25 |
| Control ... ... | — | 2 | 45 | 83 | 59·6 | 0 | 4·0 |
| Cheshunt compound | 1 oz. | 4 | 45 | 83 | 61·6 | 0 | 3·5 |
| Ditto ... ... | 2 oz. | 4 | 45 | 83 | 61·6 | 0 | 5·25 |
| Control ... ... | — | 4 | 45 | 83 | 61·6 | 0 | 7·25 |
| Uspulun ... ... | 0·25% | 4 | 45 | 83 | 59·6 | 0 | 3·5 |
| Control ... ... | — | 2 | 45 | 83 | 59·6 | 0 | 4·0 |

Of the substances tested several had a favourable influence on the course of the disease. Of these, a mixture of magnesium carbonate and lime in equal parts, potassium permanganate and ferrous sulphate are the most promising. Potassium nitrate and ammonium sulphate were tested at the end of the experiment and the results suggest that the manurial effect of these salts are mainly responsible for the improvement in treated plants. On the other hand, ammonium carbonate and Cheshunt compound, tested at the same time, appear to be beneficial since the effect was greatest at the lower concentrations. Calcium chloride is beneficial at low concentrations only.

Further experiments will be necessary to determine the value of these substances under commercial conditions. Such experiments will be carried out as opportunity arises, together with tests of other substances on pot plants during the coming season.

## 3. Botrytis Stem Rot of the Rose.

P. H. Williams.

A parasitic strain of a species of *Botrytis* attacking the rose has been noted this year. It causes a superficial brown scar on the flowering shoot, eventually girdling it and causing it to fall over. The affected tissue becomes hard and contains the mycelium of a fungus.

When the diseased tissue was placed in a moist chamber, the fungus grew out and pure cultures were easily obtained. Young flowering shoots were inoculated by pricking in the mycelium of the fungus and covering with tin foil. Inoculated shoots placed under a bell jar had fallen over in two days, while in the open, after four days, the tissue was browned for 2 inches and had collapsed.

Other shoots were inoculated by placing the mycelium and spores of the fungus in contact with the shoot and covering with moist cotton wool and tin foil. They were then placed under moist conditions and in three days showed a brown ring under the cotton wool and later collapsed. Control shoots under the same conditions remained healthy. In all cases the fungus was re-isolated or, when placed under suitable conditions, grew out and produced typical fructifications.

The disease will probably only occur in seasons of high humidity, when conditions are suitable for the germination of the spores. Care should be taken to remove all dead tissue on which the fungus may grow and to prevent the accumulation of water on the young shoots for any length of time.

## 4. A New "Wilt" Disease of the Carnation.

W. Corbett.

Towards the end of 1926 some young carnation plants, which were attacked by an apparently new disease, were submitted for examination.

The plants which were about four months from the cutting stage, showed distinct signs of wilting, and generally presented a stunted appearance. The pith and wood of the wilted stems were brown at the base suggesting that infection takes place below soil level. The browning was not confined to the wood alone, where it had travelled for some considerable distance, but had also spread into the pith.

Two fungi, *Altenaria sp.* and *Clonostachys araucaria*, were isolated from the diseased tissues but only the *Altenaria sp.* proved to be pathogenic. Inoculations into the stems of healthy carnations were always successful and the fungus was easily re-isolated from the diseased tissue.

The causal fungus, *Altenaria sp.* might be supposed to be *A. Dianthi*, S. and H.,* but the mode of infection and size of spore present important differences. The size of the spores of *A. Dianthi* is given as 26$\mu$-123$\mu$ long $\times$ 10$\mu$-20$\mu$ wide, whereas the spores of the fungus in question are 26$\mu$-103$\mu$ long $\times$ 13$\mu$-38$\mu$ wide, the latter being shorter and wider.

**Inoculation Experiments.**

Young shoots of a healthy carnation plant were inoculated in December and complete wilting took place after a period of thirty-six days. When older shoots were inoculated complete wilting

* F. L. Stevens. "The Fungi which cause Plant Disease." Macmillan. 1913.

took a much longer period, namely, sixty-one days, though stunting of the younger and more distal shoots on these inoculated stems occurred after a comparatively short period. Young shoots inoculated in late January wilted completely in twelve days.

Young healthy carnation plants from 4-6 in. high were inoculated in the stem, below soil level, in April. All these plants wilted completely in from eleven to fourteen days, the controls remaining healthy throughout.

Another series of inoculations was done towards the end of May, when a longer time elapsed before complete wilting than in the former case, namely, twenty-one to thirty days.

From these results it would appear that temperature is an important factor and that the disease is most likely to make its appearance and do most damage in Spring and Autumn.

Healthy carnation plants were sprayed with a spore suspension of the fungus and kept in a moist chamber for two days. Pale, circular, discoloured areas with black centres up to $\frac{1}{8}$ in. in diameter appeared on the young leaves and stems, bearing a close resemblance to the spots caused by *A. Dianthi*. These spots did not spread quickly and the plants when kept in a relatively dry atmosphere, suffered no further damage.

In one case a freshly cut stem was exposed to infection by spraying with a spore suspension. The inoculated shoot died back, and young shoots growing away from the stem became stunted and eventually wilted completely.

**Growth in Pure Culture.**

Experiments on the rate of growth of the fungus in pure culture show that good growth is obtained on potato agar, Czapek's agar, hard potato agar, and Coon's agar. On the first two media very few spores are produced but on the others the fungus sporulated freely. The optimum temperature of the fungus appears to lie between 73°F. and 77°F., but at 68°F. the fungus grows reasonably fast.

Further experiments on the control of the disease are in progress.

## 5. Powdery Mildew of the Carnation.

H. L. White.

Carnation mildew, a white fungal growth on carnation plants mainly on the upper surfaces of the leaves and on the calyces was observed to be widespread in the past season. In some districts it made its appearance for the first time. The disease, while making foliage and blooms unsightly, has not become sufficiently serious to threaten the life of the plant.

**Causal Fungus.**

The fungus responsible for the disease is *Oidium sp.* The length of the spores varies between 35·96 and 60·32 and the breadth between 11·60 and 20·88. The average measurement of 100 spores was found to be 44·85 × 16·64.

**Varietal Susceptibility.**

A remarkable varietal susceptibility has been observed in connection with this disease. Pot plants of a susceptible variety and smothered with mildew have been seen only a few feet away from other plants raised under the same conditions but of a non-susceptible variety which were absolutely free. On commercial nurseries the variety Aviator is the most susceptible. The attacks single out varieties with dark blooms—both crimson and scarlet. The calyces of Topsy are frequently attacked whereas the foliage remains free.

**Environmental Conditions.**

The incidence of the disease appears largely dependent on conditions of humidity. The abnormally wet and sunless summer of 1927 was no doubt responsible for the development of this disease to a greater extent than in previous years.

**Inoculation Experiments.**

Inoculations were made by placing portions of plants covered with mildew against healthy plants. The plants so inoculated were placed in the following positions :—

(1) Cool glasshouse. Approximate temperature 65°.

(2) Moist chamber in the same glasshouse.

(3) Sheltered position in the open, with a lower temperature.

No infection was obtained in (1) and (3) and a slight but definite infection was obtained in (2). The plants so inoculated were of a highly susceptible variety. Previous inoculations with non-susceptible varieties under humid conditions gave negative results. No success has been obtained with the cultivation of the fungus on detached leaves in petri-dishes.

**Control.**

The avoidance of conditions of high humidity and air stagnation is of first importance in preventing this disease.

Dusting with sulphur and spraying with lime-sulphur or ammonium polysulphide have given satisfactory control on commercial nurseries. Ammonium-polysulphide is preferable to lime-sulphur since it leaves no deposit on the foliage.

# 6. A Disease of the Strawberry Plant.

T. Small.

This disease was first observed under glass in 1925. Its subsequent appearance in other nurseries and in the open led to a continuation of the investigation.

**Disease Symptoms.**

The first symptom is a pronounced blackening of the tissues which usually appears at the base of the leaf petiole. As the disease extends the tissues collapse causing the leaf to fall to the ground. Under favourable conditions the fungus grows rapidly within affected tissues, but its spread to other parts of the same plant is slow, and hence diseased plants often develop new leaves which remain healthy for a considerable time. A cursory inspection of strawberry beds may fail to detect such plants, in which case they remain centres for further infection. The root system is attacked, but the discoloration is only apparent in young roots. Flowers and berries are susceptible but the crown is very resistant.

Pycnidia are produced on the diseased tissue. The spores from these seldom infect aerial plant parts, but usually pass to the soil and spread the disease in this manner.

**The Causal Organism.**

Inoculation experiments and re-isolations have proved conclusively that the causal organism is *Diplodina lycopersici.*

**Mode of Infection.**

In most fungus diseases the mode of infection determines the approach to the problem of control.

To ascertain if the spores of *D. lycopersici* could infect aerial parts, strawberry plants and detached leaves, in moist chambers at different temperatures, were atomised with a heavy suspension of spores in water. The spores were obtained either from pure cultures or diseased tissue. The leaves were seldom infected probably because the hairs covering them caused most of the spore suspension to run off. Where infection occurred the leaves developed dark brown, well-defined spots, which gradually extended over the whole lamina and sometimes grew into the petiole. Flowers were very susceptible and died in a few days.

It appeared from these experiments that infection of the leaves by spores was a very remote possibility under natural conditions.

To determine if the disease is caused by contact with contaminated soil, plants were set deeply in soil infected with pure cultures of the fungus. Under moist conditions the leaves died in seven days and abundant pycnidia were found in the tissues of the petiole. From these experiments it was concluded that the disease originates in those parts of the plant in contact with the soil, and that the soil is the main source of infection.

**The Relation of Temperature to the Disease.**

To find the temperature most favourable to the disease plants were set in moist infected soil and placed in positions of different mean temperatures. The results showed that infection occurs over a wide range of temperature but is most destructive about 59°F. (15°C.).

**Soil Sterilisation.**

It has been shown that the soil is the main source of infection and hence, after a season of disease, soil sterilisation is necessary if the next crop is to remain healthy. So far as the work has proceeded soil sterilisation by heat is the only means of eradicating the disease.

Efforts were made to find a fungicide suitable for outdoor application. Plants were set in heavily infected soil and treated with copper sulphate (0·4 per cent solution), Cheshunt compound (0·32 per cent. solution), or uspulun (0·25 per cent. solution), in sufficient quantity to saturate the soil. In no case was the soil freed from disease.

## 7. Tomato Leaf-Mould.

T. Small.

An extensive study of tomato "mildew" or leaf mould (*Cladosporium fulvum*) has been commenced with the object of finding control measures suitable for practical application. Such measures must be based upon one or more of the following methods: (*a*) selection and cultivation of resistant varieties, (*b*) a modification of those cultural factors favouring infection and spread, and (*c*) the use of a protective spray, dust, or fumigant.

This report presents the results of variety trials and of preliminary experiments designed to determine the conditions most favourable to the disease.

**Variety Trials.**

Two hundred varieties of tomato were tested for resistance to leaf mould. The plants were inoculated with a suspension of spores in water, placed in a moist chamber for three days, and then transferred to a heated glasshouse.

Six varieties, Sterling Castle, Up-to-date, Norduke, Maincrop, Satisfaction and Frogmore Selected, showed some resistance. Sterling Castle, Up-to-date and Norduke were noted by Dr. Jagger in the twelfth Annual Report (p. 34) of this Station. These varieties were grown in house M. this year and remained relatively free from disease, although situated in the midst of severely infected plants. Unfortunately they all produced low grade fruit and hence they are being crossed with other commercial varieties with the object of raising new varieties combining disease resistance and heavy crops of high grade fruit.

The three varieties, Maincrop, Satisfaction and Frogmore Selected, exhibited marked resistance in July but when re-tested in October they proved more susceptible and further trials are necessary.

**The Development of Leaf Mould at Different Seasons of the year.**

Each month plants 9 to 12 inches high were inoculated with a suspension of spores in water and placed in a glasshouse either at once or after a period in a moist chamber. Using ten plants in each case, the average number of days between inoculation and sporulation was noted and is given in Table 1.

**Table 1.**

Showing average number of days between inoculation and sporulation at different seasons of the year.

| Month of Experiment | Hours in Moist Chamber after Inoculation. | | | | |
|---|---|---|---|---|---|
| | 0 | 24 | 48 | 72 | Constantly. |
| February and Mar. | No spores after 20 days | — | No spores after 20 days | — | 20 |
| April ... | Little or no sporulation after 20 days | — | 20 | 20 | 13 |
| May ... | Little or no sporulation after 20 days | — | — | 14 | — |
| June ... | 22 | 20 | 20 | 16 | — |
| July ... | 11 | 11 | 14 | — | 9 |
| August ... | 12 | 12 | — | 12 | — |
| September | 16 | — | — | — | — |
| October ... | 19 | — | — | 19 | — |
| Nov. and Dec. ... | No spores after 20 days ... | — | — | — | — |

The disease progressed most rapidly and was most severe in July and August, when the mean temperature of the glasshouse was 74°F. and the frequent rainfall resulted in a high relative humidity which was above 70 per cent. during the day and approached saturation at night.

From February to August the accelerated development of the disease was very noticeable.

In addition, the results showed that exposure to humid conditions for a period following inoculation favoured the disease far more in Spring than in Summer. Indeed, in the latter season the usual practice of placing inoculated plants in a moist chamber to insure infection was unnecessary.

In Winter and late Autumn hanging drop cultures showed that the conditions did not inhibit spore germination, so that at these periods primary infection presumably occurred. It is probable that the prevailing temperatures retarded the development and sporulation of the parasite. Evidence in support of this will be cited later.

**Temperature and Humidity Relations.**

These two factors are so inter-related that in the absence of special control chambers it is difficult to separate their effects on leaf mould. The conclusions from the following experiments are tentative only and merely form a basis for further research.

Plants about six weeks old were used and were atomised with a suspension of spores in water. Spores were obtained from diseased plants.

Table 2 summarises experiments designed to determine the optimum temperature for leaf mould in a saturated atmosphere.

**Table 2.**

The relation of temperature to leaf-mould in a saturated atmosphere.

| Date | Temperature °F. | | | | | Result |
|---|---|---|---|---|---|---|
| | Average | Average Max. | Average Min. | Abs. Max. | Abs. Min. | |
| 29/6/27 | 81·5 | 91·1 | 70·2 | 102 | 67 | Abundant sporulation after 12 days. |
| ,, | 76·3 | 90·7 | 61·0 | 106 | 58 | Do. |
| ,, | 74·7 | 85·7 | 62·3 | 95 | 59 | Do. |
| ,, | 67·2 | 76·2 | 57·4 | 86 | 55 | Fair sporulation after 12 days. |
| 26/9/27 | 65·9 | 77·4 | 58·3 | 83 | 55 | Fair sporulation after 14 days. |
| ,, | 61·9 | 72·0 | 54·2 | 89 | 48 | Do. |
| ,, | 55·2 | 59·4 | 50·3 | 65 | 44 | Disease scarcely visible after 21 days. |
| ,, | 50·7 | 55·9 | 42·6 | 65 | 37 | Do. |

The disease developed very rapidly at 74° to 81°F. whilst at 50° to 55°F. it was scarcely noticeable after three weeks.

The spores of *C. fulvum* germinate in water at 38°F. and would therefore, in all probability, infect the plants at 50° to 55°F. Hence it appears that the effect of low temperature is to check the subsequent development and sporulation of the fungus. This was tested by inoculating plants and placing them in a moist chamber to insure infection and afterwards moving them to positions of different mean temperatures. It should be mentioned that the humidity at the lower temperatures was equal to, or higher, than that at the higher temperatures. The results are given in Table 3 and show that sporulation is considerably retarded at the lower temperatures.

**Table 3.**

The effect of temperature on leaf-mould subsequent to primary infection.

| Date | No. of Plants | Temperature °F. | | | Result. |
|---|---|---|---|---|---|
| | | Average | Average Max. | Average Min. | |
| 22/6/27 | 6 | 74·7 | 91·9 | 59·6 | Abundant sporulation after 16 days. |
| ,, | 6 | 62·8 | 67·2 | 54·1 | Very little sporulation after 16 days. |
| 10/8/27 | 6 | 73·7 | 72·0 | 55·3 | Abundant sporulation after 14 days. |
| ,, | 6 | 64·1 | 62·0 | 57·3 | Very little sporulation after 14 days. |

In another series of experiments inoculated plants were placed in either a cucumber house, tomato house or outside. Leaf mould appeared quickest in the cucumber house thus indicating that hot, moist conditions favour it.

Further experiments were made to test the effect of high humidity during the night. Two series of plants were inoculated and treated alike except that one series was placed in a moist chamber each night. This series developed leaf mould quicker and more severely.

**The Relation of Watering to the Disease.**

The progress of the disease on turgid plants was compared with that on plants just beginning to droop. Twenty-four plants were inoculated ; twelve were placed in a glasshouse at once, and twelve were placed in a moist chamber for three days and then transferred to the glasshouse. During the experiment half the first and second series were copiously watered, whilst the remainder received just sufficient water to prevent complete wilting. Two experiments were made, one of which is given in detail in Table 4, and similar results were obtained.

**Table 4.**

The relation of watering to the disease.

| Date of Experiment | No. of Plants. | Condition of Plants | Result. | | |
|---|---|---|---|---|---|
| | | | After 13 Days. | After 15 Days. | After 18 Days. |
| 23/6/27 ... | 6* | Turgid ... | Spores appearing | Spores on all plants | All severely infected. |
| ,, | 6 | Do. | Do. | Do. | Do. |
| ,, | 6* | Just beginning to droop | Do. | Do. | Do. |
| ,, | 6 | Do. | Disease scarcely visible | Disease scarcely visible | Comparatively slight infection |

* Plants placed in a moist chamber for three days after inoculation.

The results show that all plants placed in a moist chamber after inoculation developed leaf mould with equal severity. This suggests that once the parasite is established, its subsequent development within the plant is apparently unaffected by the water content. Of the plants not placed in a moist chamber after inoculation, the turgid ones developed the disease more severely. If, as suggested previously, the development of the parasite within the host is unaffected by the water content, the results indicate that the early stages of the disease are influenced by the water content of the tissues. These suggestions will be tested further.

The effect upon the disease of covering the foliage with water was tested as follows. Twenty plants were inoculated ; ten were placed in a glasshouse at once and ten were placed in a moist chamber for three days and afterwards transferred to the glasshouse. Half the first and second series were atomised daily with water whilst the rest served as controls. The results are given in Table 5.

**Table 5.**

| Date of Experiment. | No. of Plants. | Treatment. | Result. | | |
|---|---|---|---|---|---|
| | | | After 15 Days. | After 19 Days. | After 23 Days. |
| 8/6/27 ... | 5* | Atomised each morning with water | Spores appearing | Spores on all plants | Abundant spores. |
| ,, | 5 | Do. | Disease scarcely visible | Disease scarcely visible | Very few spores. |
| ,, | 5* | Control. Not atomised | Do. | Spores appearing | Abundant spores. |
| ,, | 5 | Do. | Do. | Disease scarcely visible | Very few spores. |

* Plants placed in a moist chamber for three days after inoculation.

The results show that the disease was scarcely affected by the treatment. Three days in a moist chamber after inoculation favoured the disease far more than the daily atomisation of the foliage with water. The persistence of the water on the plant was largely determined by weather conditions and it is hoped to repeat the experiments under controlled conditions.

## 8. "Mosaic" Disease of the Tomato.

W. F. Bewley and W. Corbett.

Mosaic disease is constantly found on tomato nurseries, but the extent of the damage varies considerably. Plants with bad root development, caused by disease or unfavourable soil conditions, also those unduly forced in the early stages, may suffer considerably. Usually, however, the disease does not appreciably affect the early part of the crop, represented by the five bottom trusses. The chief danger lies in its effect on the top growth; weak growth suffering greater damage than strong growth. A weak plant should be "grown on" because if it is "stopped" in the usual way, the weak shoot becomes crippled by mosaic symptoms and the plant does little further good. Even strong plants attacked by mosaic should not be severely checked. The leading side-shoot should be some three inches long before the top of the plant is removed, to ensure that succeeding growth will be sufficiently strong to withstand the effects of the disease.

Two forms of tomato mosaic are recognised in this country. One usually known as ordinary mosaic is distinguished by a pale mottling of the leaves, accompanied by some distortion. It does not affect the appearance of the fruit. The second form, aucuba mosaic, is more severe. The mottling takes the form of bright yellow patches with sharp outline, somewhat resembling the markings of *Aucuba japonica*. It cripples the foliage to a greater extent than ordinary mosaic, and by mottling the fruit reduces its market value.

The severity and extent of the disease on commercial nurseries is increased by the presence of a high water table, especially when the underground water lies stagnant in an impervious depression. Many cases of this kind have been observed when, as early as the middle of April, it has been difficult to discover one hundred healthy individuals among many thousands of plants. Breaking up the impervious subsoil, followed by steam sterilisation produces such an improvement in the health of the succeeding crop, that although mosaic disease may occasionally reappear, its effects are almost negligible.

It is obvious, therefore, that the constitution of the crop is of great importance in combating this disease.

Mosaic disease and " stripe " disease of the tomato are frequently associated on the same plant, and this has necessitated some investigation. Quite commonly plants showing symptoms of mosaic disease in March, develop a bad attack of " stripe " in later spells of hot weather. Also, plants attacked by " stripe " may be induced to grow out of it by suitable dressings of sulphate of potash. Usually the top growth shows symptoms of mosaic disease.

Inoculation experiments conducted over a period of three years are discussed below.

**Methods of Inoculation.**

In these experiments two methods of inoculation were employed, namely, the injection of expressed juice into the leaves and stems of the plants to be inoculated, and the insertion of crushed tissue into a wound made in the stem with a sterile scalpel.

When filtered juice was used as inoculum, the expressed juice was first filtered through sterile sand and paper pulp and afterwards passed through the filter candle of desired porosity.

When crushed tissue was used the outside of the tissue, usually leaf tissue, was sterilised by immersion in absolute alcohol for 10 to 15 minutes, or by immersion in 0·2 % solution of mercuric chloride for one hour.

**Experiments with Aucuba mosaic.**

In these and all other experiments both tomato and tobacco plants were used. The results of these experiments are set out in Table 1.

In the experiments included in this table the inoculum was always taken from plants showing symptoms of aucuba mosaic only. An examination of the table, however, shows that quite a large proportion of the plants inoculated, particularly the tobacco plants, developed " stripe." In many cases the symptoms of " stripe " appeared much quicker than those of mosaic, and in some the tobacco plants became so severely affected that they died a very short time after inoculation.

It will also be seen from the table that when the expressed juice of plants affected with aucuba mosaic was passed through a Pasteur-Chamberland filter candle of porosity L9, it lost its infectivity.

## Table 1.

Results of Experiments using Aucuba mosaic as the Inoculum.

| Date. | Inoculum. | No. of Plants. | Ordinary Mosaic. | Aucuba Mosaic. | Ordinary and Aucuba Mosaic. | Stripe. | Ordinary Mosaic & Stripe. | Aucuba Mosaic and Stripe. | Healthy. |
|---|---|---|---|---|---|---|---|---|---|
| 7/5/25 | Expressed juice from tomato ... ... ... | Tomato 18 | — | 8 | — | — | — | 9 | 1 |
| | ,, ,, ,, ,, ... ... ... | Tobacco 6 | — | 1 | — | — | — | 2 | 3 |
| 28/5/25 | ,, ,, ,, ,, ... ... ... | Tomato 3 | — | 3 | — | — | — | — | — |
| | ,, ,, ,, ,, ... ... ... | Tobacco 2 | — | — | — | — | — | 2 | — |
| | ,, ,, ,, ,, filtered through Doulton candle | Tomato 3 | — | 2 | — | — | — | 1 | — |
| | ,, ,, ,, ,, ,, ,, ,, | Tobacco 2 | — | — | — | — | — | 2 | — |
| 23/7/25 | ,, ,, ,, ,, ... ... ... | Tomato 4 | — | 4 | — | — | — | — | — |
| | ,, ,, ,, ,, ... ... ... | Tobacco 4 | — | — | — | — | — | 4 | — |
| | ,, ,, ,, ,, filtered through Pasteur Chamberland L9 | Tomato 4 | — | — | — | — | — | — | 4 |
| | ,, ,, ,, ,, ,, ,, ,, | Tobacco 4 | — | — | — | — | — | — | 4 |
| | Expressed juice from tobacco ... ... ... | Tomato 4 | — | 3 | — | — | — | — | 1 |
| | ,, ,, ,, ,, ... ... ... | Tobacco 4 | — | — | — | — | — | 3 | 1 |
| | ,, ,, ,, ,, filtered through Pasteur Chamberland L9 | Tomato 4 | — | — | — | — | — | — | 4 |
| | ,, ,, ,, ,, ,, ,, ,, | Tobacco 4 | — | — | — | — | — | — | 4 |
| 10/9/25 | Tissue from tomato, sterilised outside, alcohol ... | Tobacco 6 | — | — | — | — | — | 5 | 1 |
| | ,, ,, ,, ,, mercuric chloride | ,, 6 | — | — | — | — | — | 4 | 2 |
| 25/2/26 | Tissue from tomato, inoculated into stem ... ... | Tomato 8 | — | 8 | — | — | — | — | — |
| | ,, ,, ,, ,, root ... | ,, 4 | — | 4 | — | — | — | — | — |
| 27/4/26 | ,, ,, ,, ,, stem ... ... | ,, 4 | — | 4 | — | — | — | — | — |
| | ,, ,, ,, ,, root ... ... | ,, 4 | — | 4 | — | — | — | — | — |
| 7/5/27 | Tissue from tomato, sterilised outside, alcohol ... | Tobacco 6 | — | 3 | — | — | — | 2 | 1 |
| 21/5/27 | ,, ,, ,, ,, ,, ... | Tomato 6 | — | 6 | — | — | — | — | — |

In a further series of experiments tomato and tobacco plants were inoculated with the expressed juice and tissue of plants affected with both aucuba mosaic and "stripe." These results are set out in Table 2. The results here show that in the case of tomatoes, all inoculated plants developed aucuba mosaic and occasionally "stripe," whereas tobacco plants invariably developed both aucuba mosaic and "stripe."

Egg plants, *Solanum melongena*, inoculated with aucuba mosaic, developed "stripe" only, no sign of aucuba mosaic being seen.

**Experiments with Ordinary Mosaic.**

The experiments conducted with ordinary mosaic of the tomato can be divided into two classes as in the case of aucuba mosaic, namely :—

1 Ordinary mosaic alone.

2 Ordinary mosaic and "stripe."

The results of experiments using ordinary mosaic alone are tabulated in Table 3.

As will be seen by an examination of the above table 100% infection was obtained in every case but one, and that in later experiments a larger proportion of plants developed "stripe" than in the first experiments. This applies particularly to the tobacco plants.

The results given are those obtained within a month from inoculation. In cases when inoculated plants, particularly tomato plants, were kept for a longer period, a much larger proportion of the plants developed "stripe" than is shown by the tabulated results.

Table 4 gives the results of inoculation experiments using ordinary mosaic and "stripe" combined in the inoculum. Here it will be seen that quite a large proportion of the plants inoculated developed both ordinary mosaic and "stripe," and that in two cases tobacco plants inoculated with the expressed juice of a tomato plant infected with "stripe" and ordinary mosaic, developed "stripe" alone even when the juice had been passed through a Pasteur-Chamberland L3 bougie.

**Experiments with "Stripe."**

The inoculum used in the following experiments was always taken from "stripe" plants which did not show any mosaic disease. The results of the inoculation experiments are given in Table 5.

## Table 2.

Results of Experiments using Aucuba mosaic and "Stripe" as the Inoculum.

| Date. | Inoculum. | No. of Plants. | Ordinary Mosaic. | Aucuba Mosaic. | Ordinary and Aucuba Mosaic. | Stripe. | Ordinary Mosaic & Stripe. | Aucuba Mosaic and Stripe. | Healthy. |
|---|---|---|---|---|---|---|---|---|---|
| 2/6/25 | Expressed juice from tobacco ... ... ... | Tomato 3 | — | 1 | — | — | — | 2 | — |
| | ,, ,, ,, ,, ... ... ... | Tobacco 2 | — | — | — | — | — | 2 | — |
| | ,, ,, ,, ,, through Doulton candle | Tomato 3 | — | — | — | — | — | 3 | — |
| | ,, ,, ,, ,, ,, ,, ,, | Tobacco 2 | — | — | — | — | — | 2 | — |
| 3/6/25 | Expressed juice from tomato ... ... ... | Tomato 3 | — | 2 | — | — | — | 1 | — |
| | ,, ,, ,, ,, ... ... ... | Tobacco 2 | — | — | — | — | — | 2 | — |
| | ,, ,, ,, ,, through Doulton candle | Tomato 3 | — | 1 | — | — | — | — | 2 |
| | ,, ,, ,, ,, ,, ,, ,, | Tobacco 2 | — | — | — | — | — | — | 2 |
| 10/6/25 | ,, ,, ,, ,, ... ... ... | Tomato 3 | — | 1 | — | — | — | 2 | — |
| | ,, ,, ,, ,, ... ... ... | Tobacco 2 | — | — | — | — | — | 2 | — |
| | ,, ,, ,, ,, through Doulton candle | Tomato 3 | — | 1 | — | — | — | — | 2 |
| | ,, ,, ,, ,, ,, ,, ,, | Tobacco 2 | — | — | — | 1 | — | 1 | — |
| 22/10/25 | Expressed juice from tobacco ... ... ... | Tomato 2 | — | 2 | — | — | — | — | — |
| | ,, ,, ,, ,, ... ... ... | Tobacco 2 | — | — | — | — | — | 2 | — |
| 19/9/25 | Expressed juice from tomato fruit ... ... ... | Tomato 2 | — | 2 | — | — | — | — | — |
| | ,, ,, ,, ,, ... ... ... | Tobacco 2 | — | — | — | — | — | 2 | — |
| | ,, ,, ,, ,, through Pasteur Chamberland L3 | Tomato 2 | — | 2 | — | — | — | — | — |
| | ,, ,, ,, ,, ,, ,, | Tobacco 2 | — | — | — | — | — | 2 | — |

## Table 3.

Results of Experiments using Ordinary mosaic as the Inoculum.

| Date. | Inoculum. | No. of Plants. | Ordinary Mosaic. | Aucuba Mosaic. | Ordinary and Aucuba Mosaic. | Stripe. | Ordinary Mosaic & Stripe. | Aucuba Mosaic and Stripe. | Healthy |
|---|---|---|---|---|---|---|---|---|---|
| 5/5/25 | Tissue from tobacco ... ... ... ... ... | Tobacco 6 | 6 | — | — | — | — | — | — |
| | ,, ,, ,, sterilised outside, alcohol ... | ,, 3 | 3 | — | — | — | — | — | — |
| | ,, ,, ,, ,, ,, ,, mercuric chloride | ,, 3 | 3 | — | — | — | — | — | — |
| | Tissue from tomato ... ... ... ... ... | ,, 6 | 6 | — | — | — | — | — | — |
| | ,, ,, ,, sterilised outside, alcohol ... | ,, 3 | 3 | — | — | — | — | — | — |
| | ,, ,, ,, ,, ,, ,, mercuric chloride | ,, 3 | 3 | — | — | — | — | — | — |
| 12/5/25 | Expressed juice from tomato ... ... ... | Tomato 18 | 11 | — | — | 2 | 5 | — | — |
| 22/5/25 | ,, ,, ,, ,, ... ... ... | Tobacco 6 | 6 | — | — | — | — | — | — |
| 27/5/25 | Tissue from tobacco ... ... ... ... ... | ,, 6 | 5 | 1 | — | — | — | — | — |
| | ,, ,, ,, sterilised outside, alcohol ... | ,, 3 | 3 | — | — | — | — | — | — |
| | ,, ,, ,, ,, ,, ,, mercuric chloride | ,, 3 | 3 | — | — | — | — | — | — |
| 28/5/25 | Expressed juice from tomato ... ... ... | Tomato 3 | 3 | — | — | — | — | — | — |
| | ,, ,, ,, ,, ... ... ... | Tobacco 3 | 3 | — | — | — | — | — | — |
| | ,, ,, ,, ,, through Doulton candle | Tomato 3 | 3 | — | — | — | — | — | — |
| | ,, ,, ,, ,, ,, ,, ,, | Tobacco 3 | 3 | — | — | — | — | — | — |
| 22/2/26 | Tissue from tomato ... ... ... ... ... | Tomato 6 | 6 | — | — | — | — | — | — |
| 5/3/26 | ,, ,, ,, ... ... ... ... ... | ,, 3 | 2 | — | — | — | 1 | — | — |
| 30/4/26 | ,, ,, ,, ... ... ... ... ... | Tobacco 4 | — | — | — | — | 4 | — | — |
| | ,, ,, ,, sterilised outside, alcohol ... | ,, 4 | — | — | — | — | 4 | — | — |
| 3/5/27 | Tissue from tomato, sterilised outside, alcohol ... | Tomato 6 | 5 | — | — | — | 1 | — | — |
| | ,, ,, ,, ,, ,, ,, ... | Tobacco 6 | 3 | — | — | — | 3 | — | — |
| 19/5/27 | ,, ,, ,, ,, ,, ,, ... | ,, 6 | 4 | — | — | — | — | — | 2 |

## Table 4.

Results of Experiments using a Mixture of Ordinary mosaic and "Stripe" as the Inoculum.

| Date. | Inoculum. | No. of Plants. | Ordinary Mosaic. | Aucuba Mosaic. | Ordinary and Aucuba Mosaic. | Stripe. | Ordinary Mosaic & Stripe. | Aucuba Mosaic and Stripe. | Healthy. |
|---|---|---|---|---|---|---|---|---|---|
| 6/5/25 | Expressed juice from tomato ... ... ... | Tomato 16 | 9 | — | — | — | 7 | — | — |
| | ,, ,, ,, ,, ... ... ... | Tobacco 6 | 3 | — | — | — | 2 | — | 1 |
| | ,, ,, ,, ,, through Doulton candle | Tomato 16 | 7 | — | — | — | 9 | — | — |
| | ,, ,, ,, ,, ,, ,, ,, | Tobacco 6 | 6 | — | — | — | — | — | — |
| 6/6/25 | Expressed juice from tomato ... ... ... | Tomato 3 | 2 | — | — | — | — | — | 1 |
| | ,, ,, ,, ,, ... ... ... | Tobacco 2 | 1 | — | — | — | 1 | — | — |
| | ,, ,, ,, ,, through Doulton candle | Tomato 3 | 3 | — | — | — | — | — | — |
| | ,, ,, ,, ,, ,, ,, ,, | Tobacco 2 | 2 | — | — | — | — | — | — |
| 23/2/26 | Leaf tissue from tomato ... ... ... ... | Tomato 8 | 7 | — | — | — | — | — | 1 |
| | ,, ,, ,, ... ... ... ... | Tobacco 3 | — | — | — | — | 3 | — | — |
| | Root tissue from tomato ... ... ... ... | Tomato 12 | 10 | — | — | — | — | — | 2 |
| | Leaf tissue from tomato ... ... ... ... | ,, 20 | 18 | — | — | — | — | — | 2 |
| 12/4/26 | Expressed juice from tomato ... ... ... | ,, 6 | 6 | — | — | — | — | — | — |
| | ,, ,, ,, ,, through Pasteur Chamberland L3 | ,, 6 | 6 | — | — | — | — | — | — |
| | Expressed juice from tomato ... ... ... | Tobacco 6 | — | — | — | 6 | — | — | — |
| | ,, ,, ,, ,, through Pasteur Chamberland L3 | ,, 6 | — | — | — | 6 | — | — | — |

**Table 5.**

Results of Experiments using "Stripe" as the Inoculum.

| Date. | Inoculum. | No. of Plants. | Ordinary Mosaic. | Aucuba Mosaic. | Ordinary and Aucuba Mosaic. | Stripe. | Ordinary Mosaic & Stripe. | Aucuba Mosaic and Stripe. | Healthy. |
|---|---|---|---|---|---|---|---|---|---|
| 22/6/25 | Expressed juice ... ... ... ... ... | Tomato 6 | 4 | — | — | — | — | — | 2 |
| | ,, ,, ... ... ... ... ... | Tobacco 6 | 2 | — | — | — | — | — | 4 |
| | ,, ,, filtered through Doulton candle ... | Tobacco 6 | 6 | — | — | — | — | — | — |
| | ,, ,, ,, ,, ,, ... | Tomato 4 | — | — | — | — | — | — | 4 |
| 2/7/27 | Necrotic tissue from stem of tomato ... ... | Tomato 12 | 8 | — | — | — | 4 | — | — |
| | ,, ,, ,, ,, ,, ... ... | Datura 3 | — | — | — | 3 | — | — | — |
| 2/6/27 | ,, ,, ,, fruit of tomato ... ... | Tobacco 6 | 3 | — | — | 1 | — | — | 2 |
| | ,, ,, ,, ,, ,, ... ... | Tomato 6 | 4 | — | — | — | — | — | 2 |

From Table 5 it will be seen that after inoculating tobacco or tomato plants with "stripe," ordinary mosaic invariably developed although the plant from which the inoculum was taken showed no mosaic symptoms.

When plants of *Datura stramonium* were used no mosaic symptoms developed but all the plants shewed "stripe."

**The Effect of Heat Treatment on the Expressed Juice of a "Stripe" Plant.**

In this experiment the expressed juice was taken from a large striped plant shewing no signs of mosaic. The juice was first filtered through a coarse filter paper, and 5 c.c. lots of the juice were subjected to immersion for ten minute intervals in a water bath held at different temperatures. After immersion the tubes containing the expressed juice were quickly cooled to air temperature in running water.

Tomato plants were inoculated from each lot of juice and also with untreated juice. The results are given in Table 6.

**Table 6.**

| Treatment. | No. of Plants. | Stripe. | Ordinary Mosaic. |
|---|---|---|---|
| Held at 60° C. for 10 min. ... ... ... | 6 | — | 5 |
| ,, 80° C. ,, ,, ... ... ... | 6 | — | 3 |
| ,, 90° C. ,, ,, ... ... ... | 6 | — | — |
| Control, untreated juice ... ... ... | 6 | — | 6 |

From the results given in the above table it will be seen that juice from a "stripe" plant lost its power to produce mosaic disease, when heated at a temperature between 80° C. and 90° C. for ten minutes.

**Conclusions.**

1. The "stripe" and mosaic diseases of the tomato are frequently associated in the same plant.
2. When plants were inoculated with an extract from a plant shewing aucuba mosaic alone, some developed aucuba mosaic only while others developed both aucuba mosaic and "stripe."
3. Similarly inoculation with ordinary mosaic resulted in some plants developing ordinary mosaic, others "stripe" disease and others a combination of the two.
4. When plants were inoculated with an extract from a "stripe" plant, some developed ordinary mosaic, some "stripe" disease, and others both "stripe" and ordinary mosaic.
5. When the extract from a "stripe" plant was heated for ten minutes at a temperature between 80° C. and 90° C. it lost its ability to produce mosaic disease by inoculation.

# 4. Entomological Report.

## 1. Red Spider Investigations.

### (a) Spring and Summer Spraying.

E. R. Speyer.

The difficulty of obtaining large quantities of soft water on nurseries has limited the use of the soft soap and liver of sulphur mixture recommended in the Annual Report for 1926 (p. 52).

Experiments with paraffins of various types, emulsified with small quantities of agents such as calcium caseinate and soft soap have shown that oils of a fairly high specific gravity (·86 or above) and probably of high viscosity have a satisfactory killing action by contact upon the mite.

Medicinal paraffin is a type of petroleum well suited to the purpose, both in relation to its actual contact action and its seemingly innocuous properties to cucumber and tomato foliage. It is, however, difficult to emulsify and too expensive for general use.

In June, 1926, a petroleum emulsion was obtained from the United States, and after experiments on pot-plants, trials were made with cucumber plants growing in the border on a commercial nursery in April, 1927.

The emulsion contained about 83% petroleum of specific gravity near ·86, and was used upon cucumber pot plants at strengths of one part by volume of the emulsion in respectively 80, 95, 100, 120, 140 and 200 parts water.

In no case was any injury to the plant recorded. A glossy appearance of the foliage was apparent for many days after spraying, and it seemed that the leaf tissues actually absorbed some of the paraffin.

The greatest number of mites were killed with concentrations between 1 in 80 and 1 in 100; below the latter but few were killed. No eggs hatched, subsequent to spraying, with a concentration of 1 in 80, but only at this strength were the eggs killed with certainty.

On plants the foliage of which had been damped over just before spraying, the action of the emulsion upon the mite was considerably slower than on plants with dry foliage. When saponin was added to the spraying water, the killing action was very considerably reduced.

Mites on the foliage became covered with paraffin, which broke from emulsion soon after contact with the leaf surface. Death of the active stages of the mite did not ensue immediately, and in some cases adults and young were seen to move four days after receiving a coating of oil. For this reason it is not possible to give figures of the number of mites killed at various concentrations, but the number of mites covered with oil upon the leaf of a plant sprayed with a concentration of 1 in 80, 24 hours after application, may be gathered from the following :—

| Covered with Oil. | Larvae. | Proto-nymph. | Deuto-nymph. | Adults, Female. | Total. |
|---|---|---|---|---|---|
| Acting stages ... | 2 | 5 | 4 | 3 | 14 |
| Resting stages ... | 5 | 13 | 3 | — | 21 |
| Not covered with Oil. | | | | | |
| Active stages ... ... | — | — | 2 | 1 | 3 |
| Resting stages ... | 1 | 1 | — | — | 2 |

On the assumption that the individuals covered with oil eventually died, and very few were found living five days after application, the mortality obtained was about 87%, which, for a spray, is exceedingly high.

An emulsion consisting of Medicinal Paraffin (sp. gr. ·89) 234 parts, water 41 parts, by volume and calcium caseinate 4 parts and potash soft soap 1 part by weight, emulsified by means of a syringe and diluted to 1 part emulsion to 80 parts water gave results similar to those obtained with the previous emulsion.

In June, 1927, one side of a cucumber house 100 feet in length was sprayed with the previous emulsion at a strength of 1 pint emulsion to 10 gallons water, with most satisfactory results. The other side of the house was sprayed with a similar dilution, but ½ ounce saponin was added to the water as a spreader. Though a good mortality of the mites was obtained, the addition of the spreader decreased rather than increased the effectiveness of the emulsion.

It is probable that the presence of a spreader may cause the oil to run from the leaf surface without coating the mites upon the foliage.

Ordinary burning paraffin 1½ pints, with 1 ounce potash soft soap dissolved in ½ ounce fusel, oil makes a very stable stock emulsion when 6 fluid ounces of water are slowly stirred into the mixture : but red spider mites were not killed by this upon tomato foliage when the stock was used at strengths up to 1 part to 15 water by volume, and considerable scorching of the leaf tips ensued at the latter concentration.

Medicinal paraffin may be easily emulsified in small quantities by adding 16 fluid ounces of the latter gradually to 2 ounces soft soap dissolved in 1 ounce fusel oil and finally stirring in 2 fluid ounces water.

Though not injurious to the foliage, this emulsion, used at a strength of 1 in 80 by volume, was not as effective as the emulsion mentioned previously, when calcium caseinate and soft soap were used in small proportions and a syringe used for emulsification.

Paraffin oil emulsions cannot be used advantageously upon the carnation plant, as they remove the bloom from the foliage, and the mites do not receive a sufficient quantity of paraffin upon them to cause death.

## (b) Experiments on Commercial Nurseries.

O. Orchard.

Investigations have been commenced on nurseries, for the purpose of studying the habits of Red Spider in glasshouses. The following is a preliminary report of this work.

### Migration of the Red Spider Mite.

The first week of August, 1927, was very bright and warm, following a period of dull wet weather at the end of July. On the morning of the second sunny day, examination of a large number of low cucumber houses on various nurseries showed that the Red Spider mites were leaving the insides of the houses in great numbers, and moving to the tops of the ridge boards, where they appeared to bask in the sun, but on close examination they were found to be blown away singly on fine strands of web by the slightest puff of wind. These migrating forms, which continued to leave the houses for a period of four days, were adult males and females, the latter being in the majority. To ascertain whether these mites were leaving the old plants in search of food or in search of hibernating quarters outside, a number were placed on isolated plants of Runner Beans. They at once began to lay eggs, after which many of them died. Sixty small bundles of straw were tied to the ends of the ridge-boarding, where the Red Spider congregated, to determine if they would hibernate. The traps remained free from spider during the 64 days of the experiment.

Twenty Red Spiders were placed on a small bundle of straw, tied to an iron stake, and isolated on a heap of lime, away from vegetation. After a period of two days they had left the straw, having, in all probability, been blown away by the wind.

During August straw was placed along the ridging in the tops of tomato houses for the purpose of trapping the spider. It was left in position until the houses were cleaned, but was never found to contain more than a few spider.

On a few nurseries only did a migratory phase occur in tomato houses at this time of the year and, as spider brought to the Experimental Station and placed on carnation, strawberry, and tomato plants could not be induced to hibernate, but continued to breed, it seems safe to conclude that the migration was merely a phase, induced by the sudden rise of temperature at a time when the plants were ageing. It did not occur in houses containing young plants.

**Weeds as a Source of Infection.**

Weeds in the vicinity of glasshouses were examined on many nurseries and the following, on which the red spider were breeding freely, proved to be favourite host plants : Dandelion (*Taraxacum officinale*) ; Elder (*Sambucus nigra*) ; White Clover (*Trifolium hybridum*) ; Black Nightshade (*Solanum nigrum*) ; Common Dock (*Rumex obtusifolius*) ; Thistle (*Cnicus spp.*) ; and Runner Bean (*Phaseolus multiflorus*). It is obvious therefore that these plants should not be allowed to grow in the neighbourhood of glasshouses. Further, weeds should not be allowed to grow near stacks of staging during the summer. A heap of staging which had been lying in the open since being taken from the propagating houses last season, and around which weeds had been growing freely, was examined on the 26th January, 1928, and a number of living red spider were found on the drier parts of the woodwork. The necessity of thoroughly cleaning all staging before it is taken into houses for use is therefore evident.

**Trapping with Straw.**

By the courtesy of Messrs. C. J. Randall, and C. H. Shoults, experiments have been carried out with straw as a means of trapping spider when they commence to seek hibernating quarters, with the object of reducing the number that reach inaccessible cracks, etc. The results obtained varied considerably according to the temperature of the houses, and the amount of spider present on the plants. It must be remembered that only forms of the mite which have turned red prior to hibernation can be expected to enter straw.

During the third week in August, straw was spread over the ground in one half of a badly infected tomato house, 200 feet long by 30 feet wide, the other half being covered with an ordinary dung mulch. Heat was applied to this house, about the middle of September, and no red forms of spider were found on the

plants until the 28th of the month. Before this date, no spider could be found in the straw, but, immediately red forms were found on the plants, the movement into the straw was very rapid and in a week's time every piece contained numbers of spider. At the end of the experiment one pound of straw, and one pound of straw residue from the mulch in the same house, were brought to the laboratory, and counts made of the Red Spider which they contained. Greater numbers were found in the straw than in the straw residue, and, as the latter is more difficult to sweep up after the crop has been removed, it is preferable to use the former.

Straw was spread in another house on the same nursery during the first week in September, but in this case, the house was not heated. It was found that the spider turned red and began to hibernate exactly one week earlier in unheated houses, than they did in heated houses, also that the movement into the straw was one week earlier. Small parcels of straw were taken from each house for examination, and the following figures show that more Red Spider had collected in the straw of the heated house than in that from the cold house.

| Weight of Straw Examined. | Condition of House. | Number of Spider. | Calculated Number of Spider per Cwt. Straw. |
|---|---|---|---|
| 1 oz. | Heated | 37 | 65,000 |
| ¾ oz. | Unheated | 15 | 36,000 |

Attempts were made to destroy the Red Spider in the straw by spraying with the following :—

Cresylic acid, at a dilution of 1 gall. to 39 galls. water ; emulsified cresylic acid, at 1 gall. to 39 galls. water, and at 1 gall. to 19 galls. water. These mixtures were also used with the addition of a little methyl salicylate. In spite of careful spraying the spider within the straw remained unharmed. Similarly, live spider have been found in the straw of cucumber beds after washing down the houses with cresylic acid (1 in 40).

In another experiment, straw was spread in a house, where the crop had been kept reasonably free from the pest by spraying. As might be expected, fewer spider were trapped in the straw than in the badly infected house.

In all cases the straw was picked up and burned with the old crop.

These experiments show that the number of Red Spider which hibernate in the houses can be reduced (1) by reducing the infestation of the crop by systematic spraying with insecticides and (2) by trapping the hibernating forms in straw laid on the surface of the soil.

Care should be taken to spread the straw before the end of August, and when removing it every particle should be swept up and burned. The straw of cucumber beds should be treated with equal care.

The number of hibernating forms which reach their winter quarters also depends upon the number which are allowed to leave the plants. Mass migration does not occur until the plants are almost finished, therefore it is necessary to remove the crop at the earliest possible moment. The presence of fruit may prevent the plants from being cut down before some spider begin to leave them, but, on the other hand, too many growers leave dead plants in the houses some weeks after all the fruit has been picked, and so fill their houses with spider, which ought to be burning on the rubbish heap.

Fortunately, the Red Spider started their winter hibernation later than usual this year, and many growers had cleared their houses before it began. The benefit of this should be felt next season.

**Trapping with Corrugated Paper.**

Pieces of corrugated paper, as used for packing in tomato boxes, when rolled up and placed on the water pipes where these are fixed to the purling posts, or other woodwork, have been found to trap great numbers of hibernating spider. They should be placed in position by the middle of September and burned immediately after the crop is removed. If the water pipes are heated, spider will not enter the paper, and if already congregated there will leave the traps. On several nurseries, many thousands of spider were caught by this method after the heat was turned off at the end of the season.

**Unsuspected Places of Hibernation.**

On nurseries infested with spider, great numbers of the red hibernating forms have been found behind the ventilator hinges, and behind the hooks by which the hot water pipes are attached to the purling posts. The latter situation is a favourite one, for no fumigant or insecticide is likely to reach them. On one nursery examined, the tomato houses were thoroughly fumigated with Naphthalene immediately the last fruit was gathered, and before the plants were cut or cleared from the houses. At the end of November the whole of the woodwork was sprayed with cresylic acid and soft soap at 1-40.

About the middle of December a thorough examination of the houses was made, and, although large numbers of spider were found

in their most favoured corners, they were all dead. Fortunately, the pipe-hooks were taken from the woodwork and great numbers of living spider were found behind the hooks, especially at the back of the screw-heads.

As the other parts of the houses were so clean, it was recommended that these hooks should be loosened and the backs of them washed out with strong cresylic acid. Until recent years, this has been an unsuspected hiding place, and it is possible that it is an important source of re-infestation in the spring. Experiments are being conducted to ascertain when the spider commence to leave this position.

Similar work is being done with the outside ventilator hinges and should provide useful information. A number of hinges were removed from infested houses, the spider counted, and the hinges replaced. A ring of Tanglefoot was then placed around each so that at least a fair number of spider must be trapped as they leave the hinges.

**Movement of Overwintering Forms.**

A number of the corrugated paper traps previously mentioned were brought into the Station and kept in a greenhouse under the same conditions as those existing on an ordinary nursery. Records have been kept of the movement of the spider and it has been found that hibernating forms do not "lie dormant" all through the winter, for from the beginning of the experiment in early October a few have left the traps from time to time. Observations on a nursery bore out this fact; the slightest rise in temperature seems to stimulate movement. It has been found, however, that if the cardboard is kept moist, but not too wet, little or no movement takes place. Many spider die if sufficient moisture is lacking, and a certain amount of moisture is essential to successful hibernation.

**Winter Cleaning with Cresylic Acid.**

The use of cresylic acid wash as a means of destroying red spider in the superstructure of glasshouses has given such variable results on commercial nurseries that an attempt has been made to discover why the process has proved satisfactory in some cases and not in others. For this purpose, spider trapped in glasshouses by means of corrugated paper were brought to the laboratory and a known number were shaken carefully on to pieces of painted and unpainted wood respectively. These were sprayed with cresylic acid and emulsified cresylic acid at various dilutions, using a very fine hand spray. After treatment they were transferred to an unheated glasshouse, and seventy hours after spraying the number of dead spider was noted, the results being tabulated on the next page.

**Table 1.**

| Treatment for Spider. | Str'gth used. | Treatment of Wood. | Experiment 1. | | Experiment 2. | | Experiment 3. | | Total Per cent Killed. |
|---|---|---|---|---|---|---|---|---|---|
| | | | No. of Spider. | Per cent Killed. | No. of Spider. | Per cent Killed. | No. of Spider. | Per cent Killed. | |
| Cresylic acid | 1/50 | Unpainted | 295 | 35·6 | — | — | — | — | 35·6 |
| ,, ,, | 1/40 | ,, | 87 | 86·0 | 125 | 100·0 | 102 | 100·0 | 96·0 |
| ,, ,, | 1/20 | ,, | 100 | 95·0 | 92 | 100·0 | 128 | 100·0 | 98·0 |
| Emulsified Cresylic acid | 1/40 | Unpainted | 100 | 100·0 | 354 | 100·0 | 94 | 94·5 | 99·0 |
| ,, ,, | 1/30 | ,, | 110 | 97·0 | 116 | 100·0 | 70 | 92·5 | 98·0 |
| ,, ,, | 1/20 | ,, | 100 | 100·0 | 98 | 100·0 | 108 | 100·0 | 100·0 |
| Cresylic acid | 1/40 | Painted ... | — | — | 180 | 86·0 | 68 | 92·5 | 88·0 |
| ,, ,, | 1/20 | ,, ... | — | — | 138 | 38·0 | 77 | 50·0 | 42·0 |
| Emulsified Cresylic acid | 1/40 | Painted ... | — | — | 192 | 31·0 | 103 | 48·5 | 37·0 |
| ,, ,, | 1/30 | ,, ... | — | — | 175 | 52·0 | 80 | 49·5 | 51·0 |
| ,, ,, | 1/20 | ,, ... | — | — | 87 | 50·0 | 92 | 100·0 | 75·0 |

Examination of this table shows a good deal of variation but the following facts emerge :

1. A high proportion of spider were killed on unpainted wood, the numbers from the different experiments being fairly constant.
2. A lower proportion of spider were killed on painted wood and the numbers from the different experiments show great variation.
3. It is reasonable to assume that the different results on painted and unpainted wood are governed by some physical factor, which allows the spider on unpainted wood to be better wetted with the spray than those on painted wood.
4. On unpainted wood cresylic acid should not be used weaker than 1 in 40, but there is no need to increase the strength. There is little to choose between cresylic acid and emulsified cresylic acid.
5. On painted wood cresylic acid proved more effective than the emulsified compound.
6. Great care should be taken in preparing the 1 in 40 mixtures, because a slightly weaker dilution (1 in 50) gave a very poor result.

Observation on nurseries has shown that sufficient care is not taken by some workers in spraying the houses, for live spider have been found in corners missed by the spray. A coarse jet at the end of a long lance should be used, and the spray must be driven into every crack and corner with considerable force. The experiments with painted wood indicate that future work is necessary to improve the wetting power of the spray fluid.

**The Effect of Burying Red Spider in the Soil.**

Knowing that every piece of straw on the floor of an infested house is a possible hibernating place for the red spider, and realising that small pieces may become buried in the soil, a quantity of straw was taken from the floor of an infested house, tied into small bundles and buried at varying depths on October 28th. During a period of ten weeks 75% died or were lost in the soil, and eighteen weeks later no live spider remained. In the spring of next year, tomato plants will be grown in the soil to see if infection can come from this source.

**The Effect of Conditions upon Infestation.**

To find if any particular method of cultivation, etc., favoured susceptibility to attack by red spider, an examination of eighty-five nurseries in the Lea Valley was made during the late summer of 1927. Generally, the cooler grown, well nourished, and later planted crops of tomatoes, were less severely attacked than those planted earlier. The majority of growers had the spider fairly well under control by the use of various insecticides, while a very few were favouring the use of Naphthalene, volatilised from lamps.

**Conclusions.**

(1) The migration of red spider from cucumber houses which occurred early in August on many nurseries, was brought about by excessive heat, and the ageing of the plants.

(2) Cool grown, well nourished tomato plants have shown more resistance to spider attack than those grown under forcing conditions.

(3) With an average attack of spider, the use of straw as a means of trapping the hibernating forms is to be recommended. This should be spread over the ground at the rate of $1\frac{1}{2}$ bundles of straw in a house 200 feet long by 12 feetwide. When the crop is removed, care must be taken that the straw is completely swept up and burned.

(4) Success in winter cleaning with cresylic acid depends upon thoroughness of application. This is best obtained by spraying with either emulsified cresylic acid or ordinary cresylic acid at a strength of 1 in 40, using a coarse nozzle on a long lance which must be held close to the glass and woodwork.

## (c) Fumigation.

W. H. Read.

In an attempt to discover a fumigant for controlling red spider in tomato houses, a large number of compounds were tested in the following manner :—

A fumigating box of approximately 4 cubic feet capacity was constructed with glass sides and a tightly fitting door. Spider-infected tomato plants were placed in this chamber and a weighed amount of the fumigant was vaporised or generated by chemical action. The slight volatility at ordinary temperatures of many of the substances tested necessitated their vaporisation by heating with a very small burner.

After fumigation for the required time the plants were removed, a large number of spider of all stages transferred to a fresh leaf, and both these and the fumigated plant kept under observation. The minimum amount of the fumigant necessary to kill the spider was determined when possible, together with the effect of light and humidity both as regards the action of the substance upon spider and its effect upon the plant.

Promising substances were tested further in a house of 1,000 cubic feet capacity and in several cases the minimum time in which the mites were killed at different temperatures was determined. Whilst a number of compounds proved effective, none of those tested on a large scale were without serious action on the plants.

The results of these tests may be very briefly summarised as follows :—

**Hydrogen cyanide.**

Amounts of hydrocyanic acid equivalent to 2 ozs. of sodium cyanide to 1,000 cubic feet were almost without effect on the spider even after 7 hours' exposure at a temperature of 60°F. Spider subjected to 7 days' continuous exposure to a concentration of hydrogen cyanide equivalent to $\frac{1}{4}$ oz. sodium cyanide to 1,000 cubic feet were unaffected. Four charges of cyanide equivalent to the above amount were given during this period.

**Hydrogen sulphide.**

It was found that 100% of mites were killed by 2 ozs. of hydrogen sulphide to 1,000 cubic feet after 6 hours at 70°F. The sulphide caused severe scorch which was some time in developing and badly discoloured the paintwork in the house.

**Phosgene.**

This had no effect on the spider when used in amounts which killed the plant, *i.e.*, $\frac{3}{4}$ oz. per 1,000 cubic feet.

**Ethyl acetate, Amyl acetate, Ethyl benzoate and Chloroform.**

These had only an anaesthetic action upon the spider when used in amounts sufficient to cause severe injury to the plant. The spider rapidly recovered after being exposed for 18 hours to a concentration of chloroform equivalent to 10 ozs. per 1,000 cubic feet. It is interesting to observe in this connection that spider are able to live for at least 40 hours in the absence of oxygen.

**Naphthyl salicylate, Anthracene and Benzoic Acid.**

These were found insufficiently volatile to have any effect on the spider.

**Trichloro-acetic acid.**

This killed the plants when amounts, equivalent to 2 ozs. to 1,000 cubic feet, were evaporated, at which concentration a large proportion of the spider recovered.

**Ethyl trichloracetate.**

All active forms of spider were killed by $6\frac{1}{2}$ hours' exposure at 64°F. to 4 ozs. of ethyl trichloracetate for 1,000 cubic feet, but some of the resting stages were not destroyed under these conditions. The plants were killed—probably due to the formation of the trichloro-acetic acid by hydrolysis in the tissue.

**Chloral.**

Difficulties were encountered in experiments with chloral owing to the rapid formation of chloral hydrate. It was found, however, that more than 90% of all stages were killed by 3 hours' exposure to chloral in a concentration of $1\frac{1}{2}$ ozs. to 1,000 cubic feet. All the active stages were killed by this treatment but the plants were very badly scorched.

**Chloropicrin.**

This substance has been shown (Annual Report, 1923) to be highly toxic to both spider and plants. Experiments were made with solutions of chloropicrin in various oils to see if by controlling the rate of evaporation the injury to plants could be abolished without affecting the efficiency of the fumigant. Whilst the rate of evaporation was greatly reduced in this manner it was not possible to destroy the spider without killing the plant.

**Chloroacetone** (mono).

100% of spider of all stages were killed by 6 hours' exposure at 60°F. to a concentration of 5 ozs. per 1,000 cubic feet, the plant being killed also.

**Diphenyl-arsenious-chloride.**

This compound containing arsenic proved less toxic than was anticipated. Only 90% of the spider were killed by exposing for 3 hours to a concentration of 8 ozs. of diphenyl-arsenious-chloride to 1,000 cubic feet, which treatment proved fatal to the plant.

**Salicylaldehyde.**

Fairly large amounts, *i.e.*, 4 ozs. to 1,000 cubic feet of salicylaldehyde killed 100% of spider in 3 hours at 70°F., but caused very severe scorching. A concentration of 2 ozs. to 1,000 cubic feet was found to kill 80% of the active stages with little injury to the plant. The resting stages and eggs were not killed under these conditions.

**Ethyl p-nitrobenzoate.**

It was found that when the equivalent of 2 ozs. of ethyl-p-nitrobenzoate was volatalised by heating it condensed to form a fog of solid particles which were deposited as a very fine film on the leaves of the plant. No spider recovered after 4 hours' exposure at 60°F. to this treatment. The tomato plants treated in this manner were only very slightly scorched, a cucumber plant subjected to similar treatment was, however, rather severely scorched. This substance will be tried out on a larger scale during the present year, but it is anticipated that difficulties will be encountered in obtaining satisfactory distribution in larger houses.

**o-Chloroaniline.**

95% of active stages were killed by 5 hours' exposure at 70°F. to 3 ozs. of chloroaniline to 1,000 cubic feet. This concentration caused severe scorching of tomato plants. Tests, using 2 ozs. per 1,000 cubic feet showed that only approximately 50% of the spider are destroyed and the plant is injured.

**2 : 4 dichloroaniline.**

These experiments were made late in the year and difficulty was encountered in obtaining a suitable number of spider, very few young stages being available. Tests showed that 92% of the active forms were killed in 5 hours at 51°F., using $1\frac{1}{2}$ ozs. to 1,000 cubic feet, and 100% in the same time when 2 ozs. per 1,000 cubic feet were employed, the temperature in this case being 57°F. In view of these results further experiments will be made with this compound.

**s-trichloroaniline.**

All the active stages of spider were killed by $4\frac{1}{2}$ hours' exposure at 67°F. to $1\frac{3}{4}$ ozs. of trichloro-aniline to 1,000 cubic feet. Many of the resting stages and eggs were not destroyed by this treatment. The fumigant when volatalised condensed on the leaf surface in small crystals but only very slight scorching of the extreme edges and tips of the leaves resulted if the plant was kept dry.

**Paradichlorobenzene.**

The active stages of spider were found to be killed by ¾ hour exposure to an atmosphere saturated with p-dichlorobenzene at 73°F. both under dry conditions and when the atmosphere was saturated with moisture. An exposure of 3 hours under these conditions was necessary to destroy the eggs. At 60°F. the time required to kill all active stages under similar conditions was 2½ hours.

Tests made on a larger scale indicated that all the adult male and female spider recovered after 5½ hours' exposure at 64°F. to an amount of p-dichlorobenzene equivalent to 7½ ozs. per 1,000 cubic feet ; the fumigant being rapidly evaporated with a lamp. This concentration sufficed to kill the larvae and nymph stages but not resting stages and eggs, whilst the plant is severely injured.

It appears therefore that a very high concentration, which the plant is unable to stand, is required to kill the spider. In addition, it was found that the p-dichlorobenzene imparted a slight taste to the fruit which rapidly disappeared on exposure to air.

**Fumigations with Methyl salicylate.**

A large number of fumigations were carried out with methyl salicylate both in the laboratory and in glasshouses. The relative efficiencies of ethyl and methyl salicylates were first investigated, the results being as follows :—

| Duration of Exposure to a Saturated Atmosphere. | Effect on Spider (Adults). | |
|---|---|---|
| | Ethyl Salicylate. | Methyl Salicylate. |
| 1½ hours at 73° F. ... | 100% killed | 100% killed |
| ¾ hour at 73° F. ... | 70% ,, | 85% ,, |
| ,, ,, ... | 94% ,, | 95% ,, |
| 1 hour at 65° F. ... | 82% killed | 83% killed |

As the two salicylates were found to have almost equal value further experiments were conducted solely with methyl salicylate on account of its slightly lower boiling point and decidedly lower cost. Preliminary laboratory experiments showed that under carefully controlled conditions a 100% kill of active forms together with a high percentage mortality of resting stages and eggs could be obtained by the evaporation of methyl salicylate. An exposure of 4 hours at 62°F. to a concentration of 3½ ozs. to 1,000 cubic feet was found to destroy all active stages with little injury to strong plants. As a result of many house fumigations, however, it was found that when methyl salicylate was used in amounts sufficient

to ensure the killing of a high percentage of the spider very severe injury was caused to soft plants and plants with poor root action. Difficulties in distribution were also encountered when methyl salicylate was tried out on a large scale with a view to its adoption as a winter fumigant.

**Fumigation with Naphthalene.**

The minimum exposure required to kill spider in an atmosphere saturated with naphthalene vapour, both when devoid of moisture and also when saturated with moisture, was determined at different temperatures. The results show that the period required is greatly reduced by increased temperature and the presence of moisture still further reduces the period at the higher temperatures.

The results obtained are as follows :—

Number of hours required to give 100 % mortality.

| Temperature. | In Absence of Moisture. | | Saturated with Moisture. | |
|---|---|---|---|---|
| | Adults. | Eggs. | Adults. | Eggs. |
| 100° F. ... | ½ | 8 | ½ | 8 |
| 90° F. ... | 1¼ | 22 | 1·0 | 20 |
| 80° F. ... | 4·0 | — | 3·0 | — |
| 60° F. ... | 6·0 | Not killed in 30 hours | 6·0 | Not killed in 30 hours |

Suggestions were made that the action of the naphthalene was due to its deposition on the spider. Under no conditions was there found any deposit of naphthalene on the spider when examined under a high power microscope.

Experiments were also made in which it was shown that the mortality in one batch of spider placed in a saturated atmosphere of naphthalene vapour in which more naphthalene was evaporated with a lamp was not appreciably greater than that for a second lot of spider which were placed in a normally saturated atmosphere at the same temperature and for the same period.

**Fumigation with Cresylic Acid for Winter Treatment.**

The vapour of cresylic acid is highly toxic to spider, the action being the same when the vapour is evolved from a 1 in 40 cresylic acid-soft soap mixture as when pure cresylic acid is employed.

It was found that red spider, obtained from corrugated paper traps at the commencement of the hibernation period, were killed in 5 hours at 59°F. by exposure to the saturated atmospheres of vapour obtained both from pure cresylic acid and from cresylic acid soft soap mixture at a dilution of 1 in 40. Recent experiments indicate that a rather shorter exposure is required to kill spider that have been in hibernation for a considerable time and additional tests will be made to ascertain to what extent the resistance of spider to cresylic acid vapour is diminished by hibernation.

As the vapour of cresylic acid is evolved but slowly from the diluted mixtures, the concentration of vapour resulting from washing down houses with cresylic acid is unlikely to be effective unless the temperature is kept high and the house remains closed for a considerable period.

When 10 fluid ounces of cresylic acid were evaporated from a " naphthalene " lamp during a period of 5 hours in a 1,000 cubic feet house it was found that all the mites placed in exposed positions were killed, whereas those placed in crevices were unaffected although the house remained closed for 20 hours, the temperature range over the whole period being 40°-55°F. A faint odour of cresylic acid persisted in the house for approximately a week, during which time the ventilators remained open. Since the cresylic acid vapour did not penetrate into the cracks of the brick and woodwork which were sufficiently open to enable the insertion of pieces of paper carrying spider, the vaporisation of cresylic acid is not recommended as a winter treatment because washing down with cresylic acid or " emulsified " cresylic acid in the manner previously suggested is more efficient.

**Sulphur Vapour.**

As a result of preliminary experiments, in which sulphur was vaporised in a current of carbon dioxide and passed into jars of approximately 2⅓ litres capacity fitted with fans to obtain efficient mixing, it was found that an extremely fine deposit of sulphur was formed on the leaf and an almost complete mortality of spider obtained when temperatures in excess of 70°F. were employed. Attempts to vaporise sulphur on a large scale were unsuccessful owing to the spontaneous ignition of the vapour in air at the boiling point of sulphur.

**Summary of Results obtained from Fumigation Experiments.**

(1) Several compounds were found which killed spider at moderately low concentrations—*i.e.*, when present in amounts in the order of 2-4 ozs. to 1,000 cubic feet. The majority of these had a serious effect on the plant.

A rough classification of those substances which yielded a high percentage kill of spider, showing their effect on tomato plants when present in amounts sufficient to kill all the active spider in less than 9 hours at a temperature below 80°F., is as follows :—

| Effect on Plant. | Substances. |
|---|---|
| Slightly injured ... ... | Ethyl p-nitrobenzoate<br>s-trichloroaniline<br>2 : 4 dichloroaniline |
| Severely injured ... ... | Methyl salicylate<br>o-chloroaniline<br>Hydrogen sulphide<br>(Sulphuretted hydrogen)<br>Salicylaldehyde<br>Chloral |
| Killed ... ... ... | Ethyl trichloroacetate<br>Chloroacetone (mono-)<br>Chloropicrin |

Those substances which were found to have little injurious action upon the plant when present in amounts sufficient to kill all the active stages of spider will be thoroughly tested during the present year.

(2) Whilst the vapours of cresylic acid are poisonous to spider, the evaporation of cresylic acid is of little value as a winter treatment since the fumes do not penetrate the crevices where spider may be expected to hibernate.

## 2. A White-Fly Parasite

### *(Encarsia formosa* Gahan.*)*,

E. R. Speyer.

The Chalcid parasite of the greenhouse white-fly (*Trialeurodes vaporariorum*) mentioned on p. 55 of the Annual Report for 1926, was successfully bred at the Experimental Station during the winter months. To do this it was necessary to maintain a temperature not lower than 58°F., at which the white-fly was able to reproduce itself rather quicker than the parasite.

The emergence of adult parasites from infected white-fly scales kept over the winter out of doors was extremely poor in the spring, and more recent observations suggest that normal overwintering takes place in the adult stage, outside the scale. If sufficient heat is obtainable, however, the parasite will breed throughout the year without hibernation. Contrary to expectation the tobacco plant is unsuitable for breeding the parasite, as the adults will not settle upon the foliage readily. This plant has therefore become valuable as a means of keeping a stock of white-fly comparatively free from infection.

From March to October, a total of roughly 10,000 white-fly scales, each containing a parasite were distributed to a dozen different localities upon tomato foliage.

Only in one case did the parasite fail to establish itself at the first attempt in the glasshouses in which tomato branches with infected scales upon them were hung.

Most satisfactory reports of the control of white-fly by the parasite distributed in March and April to cucumber houses, in which the pest is becoming of serious importance, were received in May. By the end of April an early infestation of white-fly in the cucumber houses at the Experimental Station was completely wiped out through the agency of the parasite.

A good control of a very serious infestation was obtained in a large tomato house upon a nursery ; here parasites to the number of about 3,000 were placed in the house on June 11th. Black parasitised scales appeared upon the plants on June 27th, and the plants carried to the end of the season without resort to cyaniding or other means of control.

For the first time in the history of the Experimental Station it was unnecessary, during the season, to cyanide the old block of tomato houses, and the carbon di-oxide chambers were kept free of fly by the parasite.

In the new block, an infestation of white-fly of some severity started at the beginning of June. At the beginning of August a single fumigation was carried out, using only $\frac{1}{8}$ ounce sodium cyanide per 1,000 cubic feet space. This killed the adult flies in the houses, and no further fumigation was called for. Towards the end of September, following this mild fumigation, vast numbers of adult parasites were present not only upon the foliage of the tomato plants, but also upon the leaves of trees and shrubs outside in the vicinity of the houses.

From this time onwards a marked decrease in the percentage of parasitised scales took place, coincident with a fall in temperature, and it appeared that the adults had ceased laying eggs and were preparing for hibernation.

The most promising record to hand relates to the presence of the parasite upon nurseries to which no distribution had been made; in October, nurseries were visited up to a distance of 3 miles from the Experimental Station, and wherever any white-fly were present, the parasite was found also. This indicates that the adult parasite is able to find its way into glasshouses of its own accord, and is also able to travel considerable distances from nursery to nursery. On the other hand, it is considered that the number of parasites which would find their way into houses of their own accord early in the year is insufficient to lay a basis for the complete control of white-fly.

It is therefore necessary to breed the parasite during the winter months in a specially heated house, so that large numbers can be distributed to nurseries quite early in the growing season

Through a grant generously given by the Empire Marketing Board, a glasshouse suitable to the purpose was erected at the Experimental Station in October.

Though unaffected by doses of cyanide usually employed for fumigation in tomato houses, and apparently by naphthalene and nicotine fumigation as practised on nurseries, the parasite in its young and adult stages is liable to destruction from the use of oil emulsions such as are used for the control of red spider mite. But as these emulsions also kill the white-fly and its scales, and the parasite is capable of re-invading the houses from outside, the matter is not considered of any importance.

Publication. Bulletin of Entomological Research, Vol. XVII., Part 3, March, 1927, pp. 301-308. Plates XXIII.—XXV.

## 3. The Chrysanthemum Midge

### (*Diarthronomyia hypogæa* Low.).

E. R. Speyer.

The first record of this insect as a pest of chrysanthemums in Great Britain was obtained on October 12th, 1927, specimens having been brought from a nursery at Waltham Abbey. The identity of the midge was confirmed by Mr. F. Barnes, of the Rothamsted Experimental Station.

The varieties infested were Monument, Mrs. Barrel and Everlasting. Upon the following day, severely infested shoots of the variety Cheshunt White were received from a nursery near Cheshunt. On both these nurseries cuttings of the variety Monument had been obtained in the Spring of 1927. The introduction of the midge was finally traced to a grower who had brought cuttings of this variety direct from the United States some three years ago. The presence of the midge on some eight nurseries has been due to the purchase of the cuttings from a single infested nursery. A description of the pest, taken mostly from recent American Bulletins, was published in the *Gardeners' Chronicle*, LXXXII, No. 2133, p. 388, 12th November, 1927, with illustrations of the midge and of the galls formed by the grubs upon the foliage and stems.

Every effort has been made to issue to those concerned practical recommendations with a view to preventing the midge from laying its eggs upon the cuttings to be taken next year as stock.

Recommendations issued since October have been as follows :

1. Spraying with nicotine (90% commercial), 1 part to 400 parts water, to which potash soft soap is added at the rate of $\frac{1}{2}$ oz. per gallon.

   This kills the adults as they emerge from the galls and also the eggs, but is not effective once the grubs have entered the leaf tissues. It is necessary to spray twice weekly, up to as short a time as possible before the flower-buds open.

2. Removal and burning of all young growth from the base of the plant towards the end of December.

   By this means it is hoped that the danger of infection to cuttings subsequently taken will be reduced to a minimum, at the same time allowing the grower to obtain his cuttings by the end of January.

3. The cleaning up and burning of all plant refuse in the houses, together with all portions of plants cut down after flowering.
4. The destruction by fire of all old stools.
5. The dipping of cuttings before rooting, in nicotine, 1 part in 800 water without soft soap.

By spraying with nicotine and soft soap in October, a great reduction in the infestation was recorded at the end of December. The roots of badly infested plants showed no signs of galls beneath the ground surface.

Growers who find this pest on their young plants should immediately spray with nicotine and soft soap as recommended above. Petroleum emulsions had no effect in preventing the emergence of flies from the galls.

## 4. Pests of Young Cucumber Plants.

E. R. Speyer.

After potting from the seed-box in January, cucumber plants have been attacked on several nurseries by two insects. One is the caterpillar of a tortrix moth, which may be the same as that which attacks vines (*Tortrix podana* Scop) and the other is a capsid bug, *Calocoris norvegicus* Gmel.

The pink caterpillar only measures about one-sixteenth of an inch when first found on the foliage, has a black head and lets itself down upon a web when disturbed. At first holes are made in the foliage, and later a fairly regular mine is made usually on the upper surface of a leaf.

All the individuals kept under observation died before moulting a second time and fed for a period of not more than one week, though most damage was done during this period.

The capsid bug is at first of small size and greenish in colour, running actively over the foliage and upon the surface of the pot soil ; one individual will visit many plants and make punctures in the leaves which assume a mottled appearance. Later small holes develop and the foliage becomes much deformed. Two specimens were bred to maturity on cucumber plants of considerable size, and these caused serious deformity of the whole plant. In all stages the insect somewhat resembles the tarnished plant bug or " Bishop fly " of chrysanthemums, both in habit, and in the nature of its depredations.

Under normal cucumber house conditions there is little fear of the bug breeding.

Both insects mentioned have occurred together in propagating houses the staging of which has been carelessly thrown and kept amongst weeds during autumn or winter.

Seeing that some tortrix caterpillars hibernate in the first larval stage, under pieces of bark or wood, and that the Capsid bug lives naturally upon a variety of weeds, there can hardly be a doubt that the presence of both in propagating houses is due to dirty staging.

Further, red spider mite and grubs of the cucumber root fly have been found upon such staging.

The remedy to prevent such undesirable introduction is the storage of staging in a dry shed during the *whole* time that it is not in actual use.

## 5. The Vine Tortrix *(Tortrix podana* Scop.*).*

E. R. Speyer.

Owing to the very serious losses from damage by caterpillars of the Vine Tortrix moth in certain vineries where many bunches of grapes are ruined, electric lights with a tray of water covered with paraffin were kept alight at night from the middle of April onwards through the spring and summer.

Moths were first caught in the traps on April 20th, in a block of houses which had been heated from the end of January onwards. The following table gives the dates of other first flights of the moths in different blocks of houses :—

| Heating Begun. | | First Appearance of Moths. | | Interval after First Heating. |
|---|---|---|---|---|
| March 10 | ... | May 2 | ... | 53 |
| ,, 26 | ... | ,, 4 | ... | 39 |
| April 5 | ... | ,, 12 | ... | 37 |
| ,, 12 | ... | ,, 19 | ... | 37 |

Adult moths of the first generation which have developed from the hibernating caterpillar situated in crevices of the bark, may therefore be expected at the end of April and during May, some five weeks after heating is started.

On May 19th, 1927, 234 moths were collected from the traps in 35 houses. The following table shows the proportion of sexes :—

| Heating Begun. | Males Caught. | Females Caught. | Percent. Males. | Percent. Females. |
|---|---|---|---|---|
| Jan. 28 ... | 17 | 7 | 71 | 29 |
| Feb. 26 ... | 22 | 4 | 85 | 15 |
| Mar. 10 ... | 75 | 13 | 85 | 15 |
| ,, 12 ... | 49 | 16 | 75 | 25 |
| ,, 26 ... | 18 | 2 | 90 | 10 |
| April 5 ... | 11 | 0 | 100 | 0 |
| Total | 192 | 42 | 82 | 18 |

It will be seen that the percentage of males is very high, and in the autumn no improvement occurred in the condition of the bunches over the previous year, although as many as 120,000 moths were trapped during the whole period when the vines were in foliage.

Light traps therefore cannot be recommended for the control of these Tortrix moths.

Female moths are attracted to jars containing beer, treacle and sodium fluoride as used in the control of the tomato moth, before laying their eggs, and some control could be expected from this practice if some dozen jars were used to each house of 100 ft. length, and the diameter of each jar were not less than $2\frac{1}{2}$ inches.

The most effective control, however, is obtained by spraying with 6 lbs. lead arsenate paste and $2\frac{1}{2}$ ounces Saponin to 100 gallons water. Repeated applications are necessary for several weeks after the first foliage appears.

## 6. The Greenhouse Leaf-hopper

*(Erythroneura parvula* Boh.*).*

E. R. Speyer.

A very common pest of primulas and geraniums, and exceptionally injurious to mint, this insect causes mottling of the foliage.

To chrysanthemums it causes little damage, and on cucumber foliage it has been recorded but once.

In some cases control has been obtained by fumigation with tetrachlorethane. This liquid must never be used in houses when chrysanthemums and certain varieties of pelargonium are grown, as the vapours are usually very injurious to these plants even if small quantities of the fumigant are employed. Not more than five fluid ounces tetrachlorethane per 1,000 cubic feet poured on the path of the house are recommended in houses where fuchsias, geraniums, salvia and heliotrope are grown, as these plants are subject to injury from larger quantities. Ten fluid ounces per 1,000 cubic feet is the greatest amount that can safely be used upon any type of plant.

# 5. Carbon Dioxide Investigations.

H. L. White.

## 1. Experimental Results.

During the earlier years of these experiments to ascertain if an increased yield can be obtained by enriching the atmosphere of glasshouses with carbon dioxide, it was customary to liberate the carbon dioxide by a mixture of acid and bicarbonate. Consistent increases in yield were obtained but for various reasons the generation of carbon dioxide in this way is unsuitable for use on a large scale or on commercial nurseries. It thus became necessary to find other sources of carbon dioxide and, in 1926, a trial was given to the Cardyox apparatus which consists of a light, portable and easily managed stove, in which is burned special charcoal fuel. In the early part of the season a chamber treated with this apparatus gave an increase of 29% over the control chambers. In view of this result all the six chambers available in the 1927 season were devoted to a more extensive trial of this method.

**Experiments for the 1927 Season.**

In addition to a further trial of the Cardyox apparatus, the experiments were designed to ascertain if treatment was necessary after June. House X was used as in previous years and each chamber contained 56 plants, variety Balch's Ailsa Craig. The plants were treated in the usual commercial manner and were stopped at the fifth truss. The treatment was as follows :—

X1 and X4 Cardyox apparatus used from 1st April to 30th September.

X2 and X5 Control chambers.

X3 and X6 Cardyox apparatus used from 1st April to 30th June.

Five blocks of fuel were burned twice daily (9 a.m. to 11 a.m. and 3 p.m. to 5 p.m.) in each treated chamber, giving a concentration of 0.18 per cent. carbon dioxide for at least $1\frac{1}{2}$ hours.

The results are summarised in Table 1.

The results show that increased crops were obtained in the treated chambers and that the increase was greatest where treatment was continued throughout the season.

**Table 1.**

| Chamber. | Treatment. | Lbs. per Plant. | Tons per Acre. | Relative Values. |
|---|---|---|---|---|
| X1 | Cardyox apparatus twice daily* from 1st April to 30th Sept. ... | 7·00 | 42·00 | 115 |
| X4 | Cardyox apparatus twice daily from 1st April to 30th Sept. ... | 7·13 | 42·78 | 117 |
| X3 | Cardyox apparatus twice daily from 1st April to 30th June ... | 6·78 | 40·68 | 112 |
| X6 | Cardyox apparatus twice daily from 1st April to 30th June ... | 6·41 | 38·46 | 106 |
| X2 | Control ... ... ... ... | 6·09 | 36·54 | — |
| X5 | Control ... ... ... ... | 6·04 | 36·24 | — |
| | Average of Controls ... ... | 6·06 | 36·39 | 100 |
| | Average treated ... ... ... | 6·83 | 40·98 | 113 |

* 9 a.m. to 11 a.m. and 3 p.m. to 5 p.m.

The monthly pickings are given in Table 2, and show that for the last three months the chambers treated for the whole season produced 30% (Aug.), 20% (Sept.), and 31% (Oct.) more fruit than the chambers treated for half the season. Indeed, the latter gave only a negligible increase of 3% over the controls during these months.

In the Eleventh Annual Report, p. 120, it was shown that the increase in crop was most evident in June and September. This year, as shown in Tables 2 and 3, the increase was obtained mainly in July and September, with the exception of X1, where it occurred in August and October. The plants in X1 were much retarded in the early part of the season by reason of a failure of the heating system.

**Table 2.**

| Period of Treatment. | Chamber. | Lbs. per Plant. | | | | | |
|---|---|---|---|---|---|---|---|
| | | May. | June. | July. | Aug. | Sept. | Oct. |
| 1st April to 30th Sept. | X1 | 0·01 | 2·14 | 1·32 | 1·63 | 1·07 | 0·84 |
| ,, ,, | X4 | 0·05 | 2·55 | 1·47 | 1·20 | 1·15 | 0·70 |
| ,, 30th June | X3 | 0·04 | 2·50 | 1·58 | 1·03 | 1·05 | 0·57 |
| ,, ,, | X6 | 0·01 | 2·04 | 1·81 | 1·13 | 0·81 | 0·60 |
| Control ... ... | X2 | 0·05 | 2·34 | 1·03 | 1·13 | 0·89 | 0·65 |
| ,, ... ... | X5 | 0·04 | 2·27 | 1·31 | 1·09 | 0·81 | 0·53 |

**Table 3.**

Percentage Increases or Decreases in yield each month.

| Period of Treatment. | Chamb'r | June. | July. | Aug. | Sept. | Oct. |
|---|---|---|---|---|---|---|
| 1st April to 30th Sept. ... | X1 | — 7 | +13 | +47 | +26 | +42 |
| ,, ,, ... | X4 | +11 | +26 | + 8 | +35 | +19 |
| ,, 30th June ... | X3 | + 8 | +34 | — 7 | +24 | -- 3 |
| ,, ,, ... | X6 | —12 | +55 | + 2 | — 4 | + 2 |

## 2. Analysis of the Effects of the Carbon Dioxide Treatment, 1927.

An attempt has been made to analyse in detail the effect of an atmosphere enriched in respect of carbon dioxide on the fruiting of the plants. It is not confined to an increase in crop only, but is seen in other directions, including the following :—

### 1. Maturation Period.

The average for each truss of the number of days from pollination to picking of the fruit is shown in Tables 4, A and B. Six plants were marked in random positions in each chamber at the beginning of the season and these plants were considered representative of the chamber.

**Table 4 A.**

Calculated from Total Fruit Picked.

| | Truss 1 | Truss 2 | Truss 3 | Truss 4 | Truss 5 | Truss 6 | Truss 7 | Truss 8 | Truss 9 | Truss 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Average of Control Chambers X2, X5 | 59 | 67 | 73·5 | 76·5 | 70 | 69·5 | 66 | 67·5 | 68·5 | 66·5 |
| Treated Chamber X4 | 54 | 59 | 69 | 73 | 69 | 67 | 71 | 69 | 66 | 66 |
| Days gained by Treated Chamber | +5 | +8 | +4·5 | +3·5 | +1 | +2·5 | —5 | —1·5 | +2·5 | +0·5 |

**Table 4 B.**

Calculated Omitting Retarded Apical Fruit.

| | Truss 1 | Truss 2 | Truss 3 | Truss 4 | Truss 5 | Truss 6 | Truss 7 | Truss 8 | Truss 9 | Truss 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Average of Control Chambers X2, X5 | 55 | 54·5 | 55 | 54·5 | 60 | 67 | 64·5 | 64 | 66·5 | 66·5 |
| Treated Chamber X4 | 53 | 52 | 52 | 54 | 61 | 63 | 64 | 64 | 66 | 66 |
| Days gained by Treated Chamber | +2 | +2·5 | +3 | +0·5 | —1 | +3 | +0·5 | —0 | +0·5 | +0·5 |

The effect of this shortening of the ripening period is greatest for trusses 1, 2, 3 and 4, while there is no appreciable difference on the " tops."

**2. Development of Top of the Plant after Stopping the Main Stem.**

The tops of the treated plants grew away more strongly and quickly than those in the control chambers. Thus the trusses from 7 onwards of the treated plants developed earlier than corresponding trusses of the control plants. This is shown in Table 5, giving the average dates of opening of the flower from trusses 5, 7, 8 and 9.

**Table 5.**

| | Truss 5. | | | Truss 7. | | | Truss 8. | | | Truss 9. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Chamber* ... | X4 | X2 | X5 | X4 | X2 | X5 | X4 | X2 | X5 | X4 | X2 | X5 |
| Date ... ... | 11·5 | 10·5 | 12·5 | 5·6 | 11·6 | 13·6 | 22·6 | 1·7 | 28·6 | 5·7 | 16·7 | 18·7 |
| Gain in Days by X4 | 0 | | | 7 | | | 7·5 | | | 10 | | |

* X2, X5 = Control Chambers; X4 = Treated Chamber.

**3. Quality of Fruit.**

There was no difference in the fruit picked in June, July and August. The percentages of Grade A (Pinks and Pink and Whites) and Grade B (Whites) picked from each chamber throughout the season are shown in Table 6.

**Table 6.**

Percentages of Grade A and Grade B.

| | X1 | | X2* | | X3 | | X4 | | X5* | | X6 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Grade ... | A | B | A | B | A | B | A | B | A | B | A | B |
| June ... | 88 | 12 | 92 | 8 | 95 | 5 | 92 | 8 | 87 | 13 | 92 | 8 |
| July ... | 85 | 12 | 91 | 9 | 86 | 14 | 84 | 14 | 80 | 19 | 84 | 14 |
| Aug. ... | 76 | 19 | 78 | 19 | 81 | 16 | 78 | 20 | 77 | 21 | 71 | 17 |
| Sept. ... | 81 | 15 | 75 | 21 | 80 | 15 | 78 | 15 | 73 | 22 | 69 | 24 |
| Oct. ... | 80 | 19 | 62 | 36 | 76 | 23 | 72 | 25 | 72 | 26 | 65 | 33 |

* Control Chambers.

It will be seen that the chambers given carbon dioxide treatment throughout the season (X1 and X4) produced 6% (Sept.) and 9% (Oct.) more fruit of Grade A (Pinks, etc.) and less fruit of Grade B (Whites) than the control chambers.

**4. Development of the Sixth Truss.**

Observations were made throughout the season on the development of the various trusses. With the exception of this truss, there did not appear to be any definite differences in degree of development. Table 7 shows that truss 6, the lowest on the top of the plant and normally a very weak truss, is better developed on the treated plants. (The following figures refer only to development and not to pollination or crop afterwards picked.)

**Table 7.**

Development of the Sixth Truss.

| | Good. | Av. | Total Good. | Bad. | V. Bad | Total Bad. | Ratio of Good and Bad. |
|---|---|---|---|---|---|---|---|
| X1 ... ... | 4 | 12 | 16 | 7 | 5 | 12 | 1·33 |
| X2* ... ... | 4 | 8 | 12 | 8 | 8 | 16 | 0·75 |
| X3 ... ... | 8 | 12 | 20 | 5 | 3 | 8 | 2·50 |
| X4 ... ... | 7 | 11 | 18 | 4 | 6 | 10 | 1·80 |
| X5* ... ... | 3 | 10 | 13 | 7 | 8 | 15 | 0·87 |
| X6 ... ... | 9 | 6 | 15 | 8 | 5 | 13 | 1·15 |

* Control.

In the above table appears the degree of development of the 6th trusses of the 2nd, 3rd, 5th and 6th plants of the 8 plants in each row which were considered representative of the chamber.

X1, the outside chamber of the house, was very late and cold in the early part of the season. Its crop did not exceed that of the Controls until August, and it has been omitted from Tables 4 and 5.

**Discussion.**

These results in general serve to show that enrichment of the atmosphere with carbon dioxide is most beneficial at periods of strain in the life of the plant and in the development and maturation of fruit hanging at these periods.

There are two such periods in the life of the tomato plant as grown commercially. The first of these occurs when the plant has been stopped and is providing sideshoots for the formation of the " top " of the plant and at the same time carries a heavy crop on the bottom trusses. This strain is normally reflected in the great difference in the number of days required from pollination to picking between the basal and apical fruits of the 2nd, 3rd and 4th trusses. This " maturation period " has been calculated both with and without the inclusion of these retarded apical fruits, and it is found that whereas carbon dioxide treatment brings about a slight reduction in the number of days from pollination to picking of the basal fruits only, it produces a much greater reduction

when the apical fruits also are included. The conclusion may be drawn that the beneficial effects of carbon dioxide treatment are more marked upon the apical fruits which are so situated as regards food supply, etc., as to suffer first in what may be termed a " period of strain."

The second period comes towards the end of the season when the plant is exhausted with the strain of continual cropping and becoming liable to the natural processes of decay. The effect of carbon dioxide treatment here is seen in the better swelling of the fruit.

These conclusions have been confirmed by plotting the weekly percentage increases in crop of treated chambers against the dates of picking. The greatest increases are found on the 5th and 6th trusses and from the 9th truss onwards. These are the trusses formed at the critical periods in the life of the plant from the point of view of fruit-bearing.

# 6. The Blooming and Fruiting Period of the Tomato Plant—Progress Report.

W. Corbett.

Work begun on this subject in 1925 and continued in 1926, has been further continued during the season 1927.

Records were made as in previous years ; these included :—

(1) the date of opening of the flower,

(2) the date of pollination of the flower, and

(3) the date of picking of each fruit.

It has been assumed that a flower is pollinated when the corolla begins to fade and shrivel.

The work of the past two years has been repeated in part. Six plants of variety E.S.1, situated in the variety trial house, were selected ; of these, two were at the end of rows at the side of the house, two in the middle of the rows and two at the path end. Records were made up to, and including the seventh truss. The plants received normal treatment in every way.

In 1925, it was found that the " maturation period " was not constant for every fruit on the plant ; instead, all the fruits of the first truss and the first six or seven fruits of the following trusses (up to the 5th truss) ripened in approximately the same length of time, whereas the later fruits of the 2nd, 3rd and 4th trusses took a much longer period to ripen. Particularly prominent was the sudden increase in the length of the " maturation period " of successive fruits of the 2nd, 3rd and 4th trusses. These results were confirmed during the season 1926. It was also found that, in the case of the abnormally robust and healthy plant, the " maturation period " of all the fruits of that plant approached a constant.

Similar results have again been obtained from the plants under observation. From the detailed analysis given in Table 1 it will be seen that in every case the " maturation periods " of all the fruits of the first trusses were practically identical. In the case of the fruits of the 2nd, 3rd, 4th and 5th trusses the " maturation period " of successive fruits on the same truss lengthens ; in a number of instances this is very prominent. Plant No. 5 shows the nearest approach to constancy of the

" maturation period," whilst plant No. 3 illustrates the sudden lengthening of the " maturation period " of successive fruits of the same truss and also the lengthening of the average " maturation period " of successive trusses up to a maximum following by a shortening. These results are probably seen to better advantage in the accompanying diagrams, Figs. 1 and 2. In Fig. 2 the sudden lengthening of the " maturation period " of successive fruits of the same truss is seen in truss 3, fruits 6 to 8, and in truss 4, fruits 5 to 8.

The " maturation period " of fruits on the 6th and 7th trusses appears to be variable, but again lengthens with successive fruits of the same truss. In this connection the length of time between the opening of the last flowers of the 5th truss and the opening of the first flowers of the 6th truss is very noticeable, being in most cases from fourteen days upwards. (See Fig. 2.)

**The Effect of " Stopping " on the Maturation Period.**

During the season 1927, records were taken in the variety trial house on plants of variety E.S.1, which were " stopped " at varying times, from the 1st truss up to the 5th truss. A detailed analysis of these records up to and including the 8th truss are given in Table 2. Examination of this Table indicates that " stopping " after either the 1st or 2nd truss is advantageous because the " maturation period " approaches a constant, 14% only of the fruit taking longer than 70 days to ripen and 30% only taking longer than 65 days to ripen. Plants stopped after either the 3rd or 4th truss show the usual " maturation period " variations previously described.

Further, when plants were stopped either after the 1st or 2nd truss there was no appreciable gap between the opening of the last flower of the truss preceding stopping and the opening of the first flower of the successive truss. This gap is very noticeable in the case of the plant stopped after the 3rd and 6th trusses.

**The Effect of Soil Temperature on the Maturation Period.**

Records were taken on plants from the plots, when the soil was electrically heated, and also on plants situated at the north end of house N as controls. The plants in this series were variety E.S.1.

The records obtained from these plants shew, that while the average " maturation period " of the fruits of the plants in heated plots is somewhat longer than usual, there is an approach towards constancy which is not exhibited in the control plots. This can be readily seen in Table 3 where figures are given from typical plants from each plot.

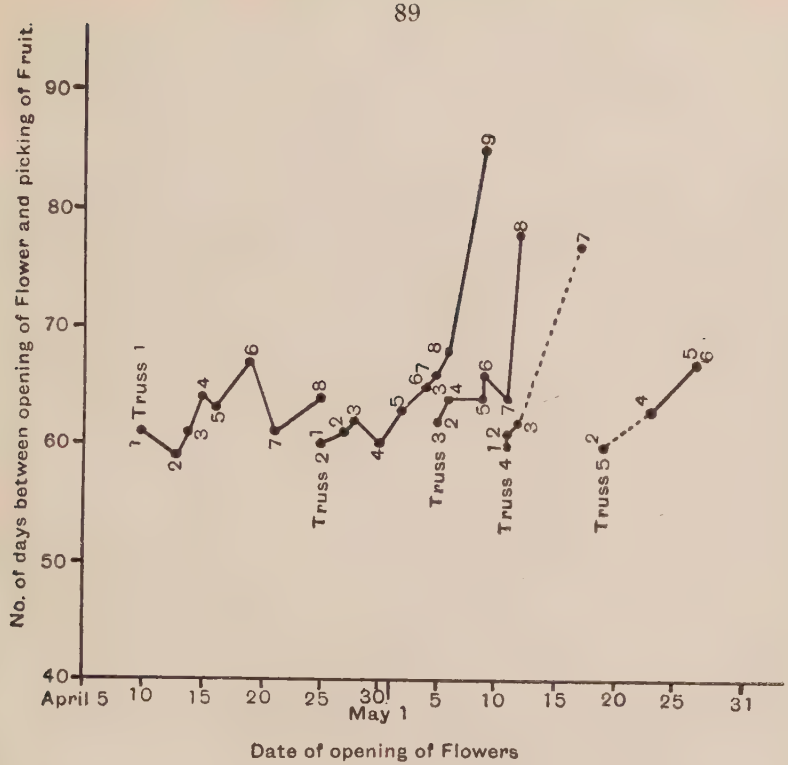

No. of days between opening of Flower and picking of Fruit.
90
80
70
60
50
40
Truss 1
Truss 2
Truss 3
Truss 4
Truss 5
April 5
10
15
20
25
30
May 1
5
10
15
20
25
31
Date of opening of Flowers

Fig. 1.

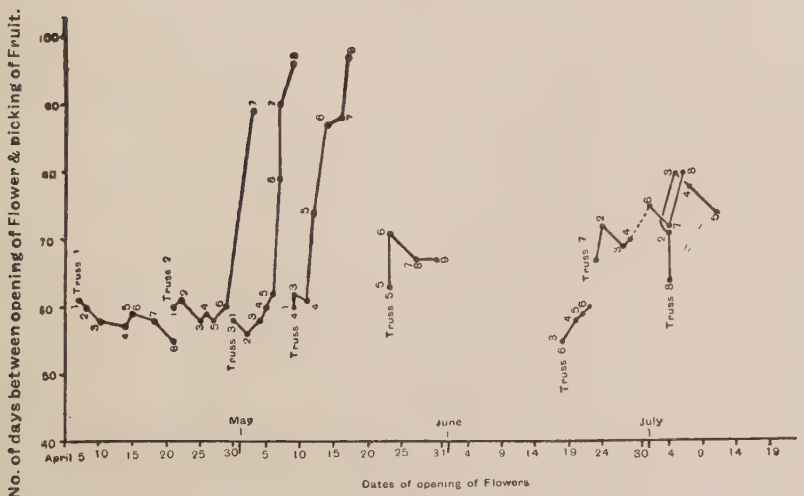

No. of days between opening of Flower & picking of Fruit.
Truss 1
Truss 2
Truss 3
Truss 4
Truss 5
Truss 6
Truss 7
Truss 8
May
June
July
April 5
Dates of opening of Flowers

Fig. 2.

**The Effect of an Atmosphere enriched with Carbon Dioxide on the Maturation Period.**

Records were taken on plants grown in an atmosphere enriched with carbon dioxide. These plants were situated in House X, chambers Nos. 1, 2, 4 and 5, chamber No. 1 being gassed from April until September, chamber No. 4 from April until June, and chambers Nos. 2 and 5 being controls. The plants were of variety Ailsa Craig.

From the records obtained it would appear that enriching the atmosphere with carbon dioxide does not affect the variations of the "maturation period." The abnormal lengthening of the "maturation period" of successive fruits of the 2nd, 3rd, 4th and 5th trusses is very noticeable.

Further work on this subject is to be carried out during the coming season.

**Table 1.** Length of Maturation Period, in Days. Variety, "E.S. 1." Variety Trial House.

| Plant No. | Truss 1 | | | | | | Truss 2 | | | | | | Truss 3 | | | | | | Truss 4 | | | | | | Truss 5 | | | | | | Truss 6 | | | | | | Truss 7 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 1 | 2 | 3 | 4 | 5 | 6 | 1 | 2 | 3 | 4 | 5 | 6 | 1 | 2 | 3 | 4 | 5 | 6 | 1 | 2 | 3 | 4 | 5 | 6 | 1 | 2 | 3 | 4 | 5 | 6 | 1 | 2 | 3 | 4 | 5 | 6 |
| Fruit | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| No. 1 | 62 | 60 | 61 | 59 | 61 | 58 | 56<br>56 | 60 | 60 | 52 | 60 | 58 | 53 | 58 | 58 | 59<br>75 | — | 59<br>65 | 61<br>60 | 59 | 60 | 79 | 60 | 60 | — | 86 | — | 80 | — | — | — | — | — | 67 | — | 67 | 73 | — | 67 | 70 | — | 81 |
| No. 2 | 60 | 60 | 60 | 59 | 59 | 61 | 56<br>53 | 58 | 61 | 52 | 61 | 58 | 55 | 56 | 56 | 61<br>81 | 62 | 60<br>80 | 60<br>61 | 58 | 60 | 65 | 61 | — | — | 84 | — | — | 60 | 73 | — | 72 | — | 65 | — | — | 72 | 59 | 72 | 84 | — | — |
| No. 3 | 61 | 60 | 58 | 57 | 61 | 58 | 55<br>55 | 59 | 58 | 51 | 62 | 60 | 59 | 62 | 58 | 60<br>108 | 64 | 62 | 63 | 63 | 62 | 65 | 62 | — | — | 85 | — | — | — | — | 71 | — | 55 | 69 | 67 | — | 71 | 62 | 69 | — | — | — |
| No. 4 | 58 | 57 | 57 | 63 | 64 | 63 | 59<br>56 | 59 | 59 | 55 | 60 | 59 | 56 | 55 | 60 | 64 | 64 | 60 | 61 | 65 | 61 | 70 | — | 78 | 75 | 89 | — | — | 63 | 74 | 71 | — | 58 | 72 | 69 | — | 79 | — | 70 | — | — | — |
| No. 5 | 56 | 62 | 59 | 56 | 63 | 62 | 57<br>54 | 59 | 58 | 53 | 63 | 61 | 62 | 64 | 62 | 80 | 64 | 61 | — | 63 | 74 | 68 | — | 81 | 78 | 86 | 63 | — | 67 | 70 | 87 | 73 | 59 | 74 | | — | 78 | 65 | — | — | — | — |
| No. 6 | 58 | 61 | 59 | 62 | 67 | 62 | 59<br>60 | 61 | 60 | 53 | 65 | 57 | 73 | 64 | 79 | 105 | 66 | — | — | — | 87 | 83 | — | 85 | 82 | 88 | 71 | — | 67 | 70 | 87 | 71 | 60 | — | | — | 82 | 70 | 75 | — | — | — |
| No. 7 | 58 | 63 | 58 | 62 | 61 | 59 | 70<br>93 | 59 | 74 | 53 | 66 | 63 | 87 | 66 | 90 | — | 64 | — | — | 76 | 88 | — | 77 | 92 | — | 88 | 67 | — | — | — | — | 74 | — | — | | — | — | 68 | 72 | — | — | — |
| No. 8 | 60 | 60 | 55 | 65 | 64 | | 92<br>100 | 61 | 89 | — | 68 | 64 | — | 69 | 96 | — | 78 | — | — | 80 | 97 | — | — | 93 | — | — | 67 | — | — | — | | | | | | | | — | 80 | | — | | |
| No. 9 | 60 | — | — | | | | — | 91 | — | — | 85 | — | — | 85 | — | — | — | — | — | 78 | — | — | — | 96 | | — | 67 | - | — | — | | | | | | | | | — | | — | | |
| No. 10 | — | — | — | | | | | — | — | — | | | | — | — | — | | — | — | — | — | — | | | | | | — | | | | | | | | | | — | | — | | |
| Av'ge | 59 | 60 | 58 | 60 | 62 | 60 | 63<br>66 | 63 | 64 | 53 | 66 | 60 | 63 | 64 | 70 | 71<br>88 | 66 | 60<br>72 | 61<br>60 | 68 | 74 | 71 | 65 | 83 | 78 | 87 | 67 | 80 | 64 | 72 | 76 | 73 | 58 | 69 | 68 | 67 | 76 | 65 | 72 | 77 | — | 81 |

**Table 2.** Length of Maturation Period, in Days, of Fruits of Plants Stopped at Varying Intervals.

| Plant No.* | Truss 1 | | | | | | Truss 2 | | | | | | Truss 3 | | | | | | Truss 4 | | | | | | Truss 5 | | | | | | Truss 6 | | | | | | Truss 7 | | | | | | Truss 8 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 14 | 15 | 16 | 17 | 19 | 21 | 14 | 15 | 16 | 17 | 19 | 21 | 14 | 15 | 16 | 17 | 19 | 21 | 14 | 15 | 16 | 17 | 19 | 21 | 14 | 15 | 16 | 17 | 19 | 21 | 14 | 15 | 16 | 17 | 19 | 21 | 14 | 15 | 16 | 17 | 19 | 21 | 14 | 15 | 16 | 17 | 19 | 21 |
| Fruit No. 1 ... ... | 61 | 61 | 63 | 62 | – | 62 | 59 59 | 62 | 60 | 62 | 58 60 | 63 | – | – 66 | 60 | 61 | 69 | 61 | 65 | – | 72 – | – | 55 | – 67 | 64 – | 66 | 66 59 | 62 | 66 | – 72 | – 66 | – | 71 78 69 | – | 60 | – – | – | 58 55 | – 70 | – | – | – | – | – | 67 80 | 70 63 |
| Fruit No. 2 ... ... | 60 | 59 | 62 | 64 | 62 | 61 | 60 54 | 63 | 60 | 59 | 62 62 | 62 | 62 | 61 63 | 63 | 65 | 65 | 63 | – | – | 70 68 | – | – | 68 | 66 – | – | 69 58 | 61 | – | – | 71 69 | – | – – | – | 63 | 60 54 | – | 59 52 | – | 50 60 | – | – | 77 | – | 79 | – 68 |
| Fruit No. 3 ... ... | 62 | 60 | 59 | 62 | 64 | 60 | 60 54 | 60 | 61 | 65 | 61 63 | 63 | 60 | 64 63 | 65 | 63 | 67 | 66 | – | – | 68 | – | 65 | 68 | – | – | – | 64 | 63 | 72 | 72 – | 69 | 72 – | 68 | 63 | 70 66 58 | – | 60 | 64 | 55 58 | 57 | – | 76 | 77 | 71 – | 77 – |
| Fruit No. 4 ... ... | 60 | 59 | 62 | 60 | 62 | 64 | 61 – | 62 | 63 | 67 | 64 67 | 61 | 63 | 63 61 | 64 | 63 | 70 | 65 | – | – | 67 | 58 | – | – | – 91 | – | 75 | 66 | – | – 66 | 74 – | 70 | 76 71 | – | 71 | 69 62 | 70 | 63 55 | 67 | 55 67 | 59 | – | 75 | 75 | 84 – | 75 78 |
| Fruit No. 5 ... ... | 63 | 58 | 62 | 66 | 66 | 64 | 65 60 | 63 | 61 | 65 | 62 66 | 61 | 64 | 64 – | 70 | 68 | 70 | 63 | – | – | 67 | 57 | 63 | 65 | – 91 | – | 79 | 68 | – | – 66 | – 70 | 76 | 83 – | – | 72 65 | – | 69 | 63 56 | 63 68 | 60 76 | 60 | – | 81 | 82 | 81 – | – – |
| Fruit No. 6 ... ... | 59 | 58 | 66 | 63 | 62 | – | 64 – | 67 | 64 | – | – 69 | 61 | 67 | 74 – | 73 | 68 | – | – | 61 | – | 67 | 63 | – | 73 | – – | 66 | – | 65 | – | – | 66 – | – | – – | – | 74 | – | – | 69 – | 66 68 | 65 – | 63 | – | 77 | 88 | 93 – | – – |
| Fruit No. 7 ... ... | 60 | 60 | 63 | 64 | 63 | 62 | – | 60 | 62 | 77 | 63 70 | 61 | 73 | – – | 77 | 81 | 77 | 78 | 62 | 67 | 67 – | 62 | 73 | 77 | 73 – | 71 | – | 72 | – | 66 | 69 – | – | – – | – | – | – | – | 69 – | 69 68 | – | 69 | 60 | – | 87 | – – | – – |
| Fruit No. 8 ... ... | 58 | 58 | 65 | 68 | 63 | 63 | – | 66 | 59 | 83 | – 72 | 63 | 75 | – – | 76 | 78 | – | – | 63 | 64 | 69 – | – | – | 76 | – | 75 | – | – | – | – | – | 72 | 65 – | 65 | – | – | – | – | – 69 | – 70 | – | – | 65 | 83 | 84 | – |
| Fruit No. 9 ... ... | 63 | 65 | 65 | 66 | – | 65 | – | 63 | 59 | 81 | – 65 | – | – | – 76 | 78 | – | – | 56 | – | – | – | – | – | 73 | – | – | – | – | – | – | – | – | – | – | – | – | – | – | 72 | – | – | – | – | – | – |
| Fruit No. 10 ... ... | 70 | – | – | | | | – | | – | – | | 68 | – | | – | – | – | | | | – | – | – | – | | – | – | – | – | | | – | | | | | | – | – | | | | – | | | |

*Continued on Page 93.*

**Table 2** (*continued*).

| Plant No.* | Truss 1 | | | | | | Truss 2 | | | | | | Truss 3 | | | | | | Truss 4 | | | | | | Truss 5 | | | | | | Truss 6 | | | | | | Truss 7 | | | | | | Truss 8 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 14 | 15 | 16 | 17 | 19 | 21 | 14 | 15 | 16 | 17 | 19 | 21 | 14 | 15 | 16 | 17 | 19 | 21 | 14 | 15 | 16 | 17 | 19 | 21 | 14 | 15 | 16 | 17 | 19 | 21 | 14 | 15 | 16 | 17 | 19 | 21 | 14 | 15 | 16 | 17 | 19 | 21 | 14 | 15 | 16 | 17 | 19 | 21 |
| Fruit No. 11 ... ... | | | – | | | | | | – | – | | 67 | – | | | – | – | | | | | – | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Fruit No. 12 ... ... | | | | | | | | | – | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Average ... ... | 61 | 80 | 63 | 64 | 63 | 63 | 60 | 63 | 61 | 70 | 64 | 63 | 66 | 64 | 70 | 70 | 70 | 66 | 61 | 66 | 68 | 59 | 67 | 71 | 77 | 69 | 67 | 65 | 65 | 68 | 70 | 72 | 72 | 68 | 67 | 61 | 69 | 60 | 68 | 61 | 62 | 62 | – | 78 | – | 80 | 80 | 72 |

* Plant 14 stopped at 1st, 4th and 6th trusses ; Plant 15 at 2nd, 5th and 7th trusses ; Plant 16 at 2nd, 5th and 7th trusses ; Plant 17 at 3rd and 6th trusses ; Plant 19 at 4th and 7th trusses ; Plant 21 at 5th and 6th trusses.

## Table 3.

Maturation Period of Plants Grown in Soil Heated to Constant Temperatures.

| | Truss 1 | | | | | Truss 2 | | | | | Truss 3 | | | | | Truss 4 | | | | | Truss 5 | | | | | Truss 6 | | | | | Truss 7 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Temp. ° F. | 65 | 70 | 75 | 80 | C* | 65 | 70 | 75 | 80 | C | 65 | 70 | 75 | 80 | C | 65 | 70 | 75 | 80 | C | 65 | 70 | 75 | 80 | C | 65 | 70 | 75 | 80 | C | 65 | 70 | 75 | 80 | C |
| Fruit No. 1 ... | 70 | 69 | 65 | 64 | 56 | 76 | 67 | 67 | 66 | 63 | 76 | 64 | 67 | 61 | 60 | 69 | 69 | 69 | 63 | 56 | 72 | 65 | — | 78 | 63 | 71 | | | — | — | 64 | 61 | 55 | 78 | 64 |
| Fruit No. 2 ... | 69 | 68 | 65 | — | 54 | 69 | 67 | 67 | 67 | 62 | 75 | 66 | 67 | 62 | 64 | 70 | 70 | 68 | 65 | 58 | 72 | — | 75 | 77 | 63 | 72 | | | 67 | — | 69 | 60 | 66 | 58 | — |
| Fruit No. 3 ... | 70 | 70 | 67 | 66 | 55 | 83 | 75 | 67 | 65 | 62 | 72 | 69 | 67 | 63 | 63 | 69 | 69 | 70 | 68 | 58 | 71 | 70 | 78 | — | 65 | — | | | 74 | 64 | — | 63 | 66 | 76 | — |
| Fruit No. 4 ... | 72 | — | 65 | 68 | 52 | 80 | 65 | 67 | 66 | 57 | 71 | 70 | 70 | 65 | 65 | 70 | 72 | 70 | 69 | 60 | 72 | 81 | 77 | — | 63 | — | | | | 60 | 71 | 68 | 69 | 57 | 64 |
| Fruit No. 5 ... | 73 | 65 | 68 | 68 | 55 | 80 | 67 | 69 | 67 | 60 | 72 | 69 | 70 | 65 | 65 | 72 | 74 | — | 75 | 61 | 79 | 78 | — | 71 | 95 | — | | | | 60 | — | 67 | 68 | 58 | 80 |
| Fruit No. 6 ... | 77 | 68 | 70 | 67 | 56 | 78 | 69 | 78 | 65 | 62 | 74 | 71 | 71 | 67 | 64 | 70 | 72 | — | 78 | 64 | — | 76 | 77 | 79 | 93 | — | | | | | 75 | | 72 | 78 | |
| Fruit No. 7 ... | 76 | 67 | 69 | — | 58 | 76 | 68 | 76 | 84 | 63 | 75 | 70 | 101 | 72 | 65 | 72 | 75 | — | 77 | 66 | 79 | 85 | 79 | — | 100 | — | | | | | 76 | | 80 | 87 | |
| Fruit No. 8 ... | 81 | 69 | — | — | 58 | 78 | 70 | — | 82 | 70 | 74 | 77 | 108 | 83 | 65 | 73 | 84 | — | 75 | 93 | 79 | — | 75 | — | 100 | — | | | | | 78 | | | 84 | |
| Fruit No. 9 ... | 83 | 68 | | | 64 | 84 | 79 | | 88 | | 86 | 77 | — | — | 64 | 88 | 79 | — | 73 | 95 | — | — | — | — | 98 | | | | | | — | | | 82 | |
| Fruit No. 10 ... | | | | | | 90 | 96 | | | | — | 85 | — | — | — | — | | — | 74 | 95 | — | 83 | — | — | — | | | | | | | | | | |
| Fruit No. 11 ... | | | | | | | | | | | 96 | | — | | | — | | | | | — | | | | | | | | | | | | | | |
| Fruit No. 12 ... | | | | | | | | | | | | | | | | — | | | | | — | | | | | | | | | | | | | | |
| Average ... | 74 | 68 | 67 | 67 | 56 | 79 | 72 | 70 | 72 | 62 | 77 | 72 | 77 | 67 | 64 | 73 | 74 | 69 | 72 | 74 | 75 | 77 | 77 | 76 | 82 | 71 | — | — | 70 | 61 | 72 | 64 | 65 | 73 | 70 |

Truss Missed

Truss Missed

* C—Control plant in unheated soil.

# 7. Chemical Report.

O. Owen.

## 1. The Amount of Nitrate nitrogen in the Soil of some of the Experimental Plots.

It is generally accepted that most plants, including the tomato plant, take up their nitrogen mainly in the form of nitrate. Having regard to the importance of nitrogen as a manure for the tomato plant, it is necessary to know something of the factors which influence the processes of nitrate formation in tomato soils.

Originally it was intended to determine whether the addition of phosphates affected nitrate production, but once the method of analysis was decided upon it was considered worth while to examine a number of plots in the old block of tomato houses and three plots in the block of houses erected at the end of 1922.

In the old block the following plots were selected, in which the respective manurial applications consisted of :—

| | | |
|---|---|---|
| (1) | Complete Artificials less nitrogen ... | (K7B) |
| (2) | ,, ,, ,, potash ... | (K8A) |
| (3) | ,, ,, ,, Phosphates ... | (K6B) |
| (4) | ,, ,, ... ... ... | (K5B) |
| (5) | Double complete artificials ... ... | (K1B) |
| (6) | No manure ... ... ... ... | (K2B) |

*All these plots carried tomato crops during* 1927.

In the newer block of houses the following plots were examined:—N1B, N4B, Q4B. N1B and N5 have received dressing of lime, stable manure and artificials since the houses were built but, whereas crops have been grown in N1B, N5 has remained fallow the whole time. The plot Q5 has remained unlimed, unmanured and uncropped since the house was built.

Whenever possible samples were taken from all these plots once a week. The samples were analysed for nitrate nitrogen and water. The results are all calculated to soil dried at 100° C. On a number of occasions the amount of nitrogen present in the form of ammonia was also determined. Except immediately after top-dressing the amount of ammonia present was small and differed but little in the different plots.

The results for nitrate nitrogen in house K are shown in Table 1 and for the other plots in Table 2. The variations in the values will be best seen in figures 1 to 4.

## Table 1.

House K.

Nitrate nitrogen in parts per million of Oven Dried Soil.

| Date. | K2B Unmanured | K1B Double C.A. | K5B Complete A. | K6B No phosphates. | K8B No potash. | K7B No nitrogen. |
|---|---|---|---|---|---|---|
| 1927. | | | | | | |
| Jan. 19 | — | — | 49·46 | 100 | 116 | 13·8 |
| Feb. 10 | 87·9 | 307 | — | — | — | — |
| ,, 14 | — | — | 134 | 134 | 51 | — |
| ,, 16 | — | — | — | — | — | 79·0 |
| ,, 21 | 73·3 | 228 | — | — | — | — |
| Mar. 2 | — | — | — | — | 87·4 | 31·0 |
| ,, 8 | — | — | 50·5 | 66·4 | — | — |
| ,, 9 | 55·91 | 140·1 | — | — | — | — |
| ,, 21 | — | — | — | — | 71·5 | 87·5 |
| ,, 22 | — | — | 64·9 | 67·0 | — | — |
| ,, 23 | 54·6 | 196 | — | — | — | — |
| ,, 28 | — | — | — | — | 61·7 | 39·3 |
| ,, 29 | — | — | 63·3 | 93·5 | — | — |
| ,, 30 | 61·6 | 128 | — | — | — | — |
| April 4 | — | — | 47·3 | — | 45·9 | 61·5 |
| ,, 5 | 49·6 | 251 | — | 53·1 | — | — |
| ,, 12 | — | — | — | 26·2 | 102 | 26·0 |
| ,, 19 | 72·5 | 107 | — | — | — | — |
| ,, 20 | — | — | 104 | — | — | — |
| ,, 27 | — | — | — | — | 9·72 | 89·0 |
| ,, 28 | — | — | 90·5 | 183 | — | — |
| May 2 | 40·8 | 109 | — | — | — | — |
| ,, 9 | — | — | — | — | 79·5 | 1·59 |
| ,, 11 | — | — | 51·3 | 32·5 | — | — |
| ,, 12 | 17·5 | 65·6 | — | — | — | — |
| ,, 23 | — | — | — | — | 18·6 | 1·39 |
| ,, 24 | — | — | 26·5 | 37·7 | — | — |
| ,, 25 | 5·7 | 144·6 | — | — | — | — |
| ,, 31 | — | — | — | — | 64·13 | 5·47 |
| June 2 | — | — | 50·6 | 27·0 | — | — |
| ,, 3 | 3·39 | 60·3 | — | — | — | — |
| ,, 9 | — | — | 137 | 55·3 | — | — |
| ,, 10 | — | — | — | — | — | 9·61 |
| ,, 13 | 2·82 | 234 | — | — | — | — |
| ,, 16 | — | — | — | — | 125 | 1·38 |
| ,, 17 | — | — | 27·5 | 15·2 | — | — |
| ,, 21 | 3·42 | 89·5 | — | — | — | — |
| ,, 23 | — | — | — | — | 52·7 | 2·40 |
| ,, 24 | — | — | 42·7 | 40·3 | — | — |
| ,, 27 | 2·07 | 161 | — | — | — | — |
| ,, 29 | — | — | — | — | 125·3 | — |
| ,, 30 | — | — | 43·5 | 94·1 | — | — |
| July 6 | — | — | — | — | 63·6 | 1·83 |
| ,, 7 | — | — | 55·1 | 35·9 | — | — |
| ,, 8 | 14·5 | 82·5 | — | — | — | — |
| ,, 14 | — | — | — | — | 15·0 | ·50 |
| ,, 15 | — | — | 31·7 | 6·74 | — | — |
| ,, 18 | 3·35 | 21·7 | — | — | — | — |

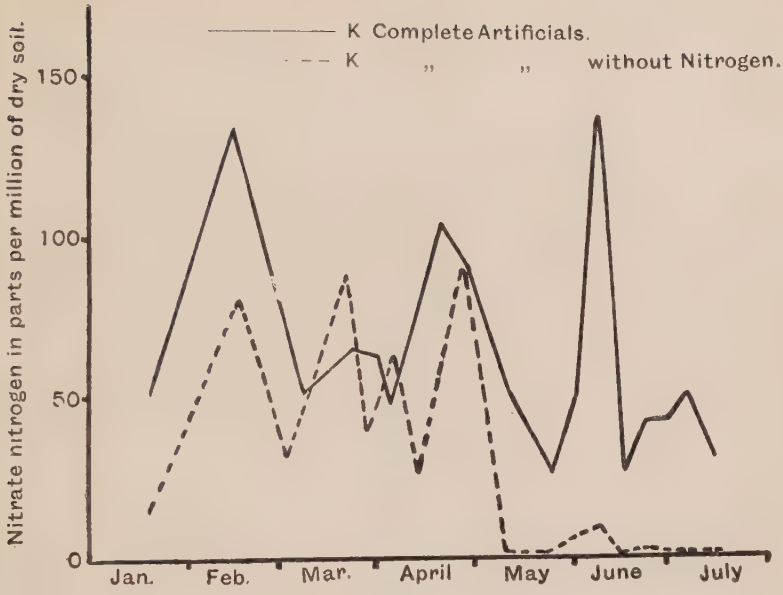

K Complete Artificials.
K „ „ without Nitrogen.
Nitrate nitrogen in parts per million of dry soil.
150
100
50
0
Jan.
Feb.
Mar.
April
May
June
July

Fig. 1.

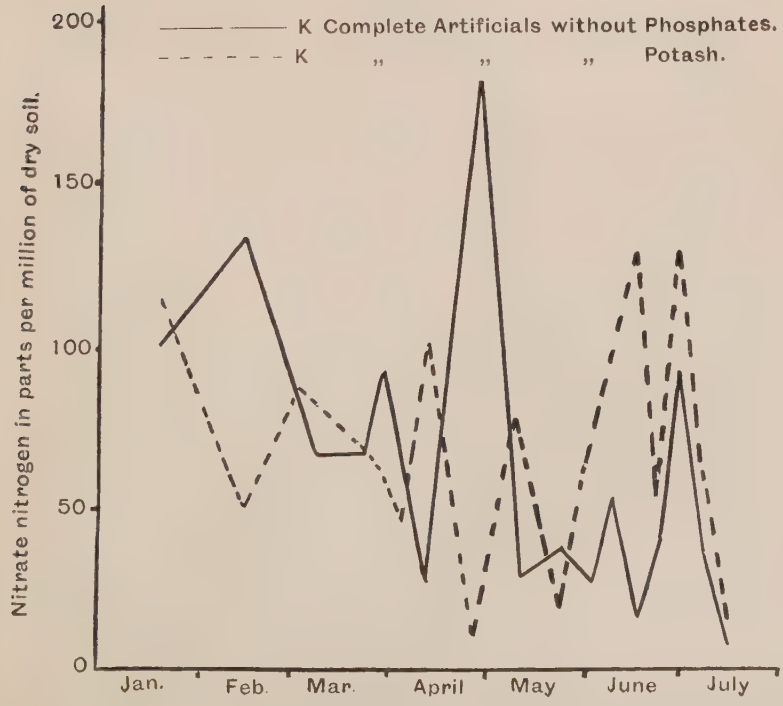

K Complete Artificials without Phosphates.
K „ „ „ Potash.
Nitrate nitrogen in parts per million of dry soil.
200
150
100
50
0
Jan.
Feb.
Mar.
April
May
June
July

Fig. 2.

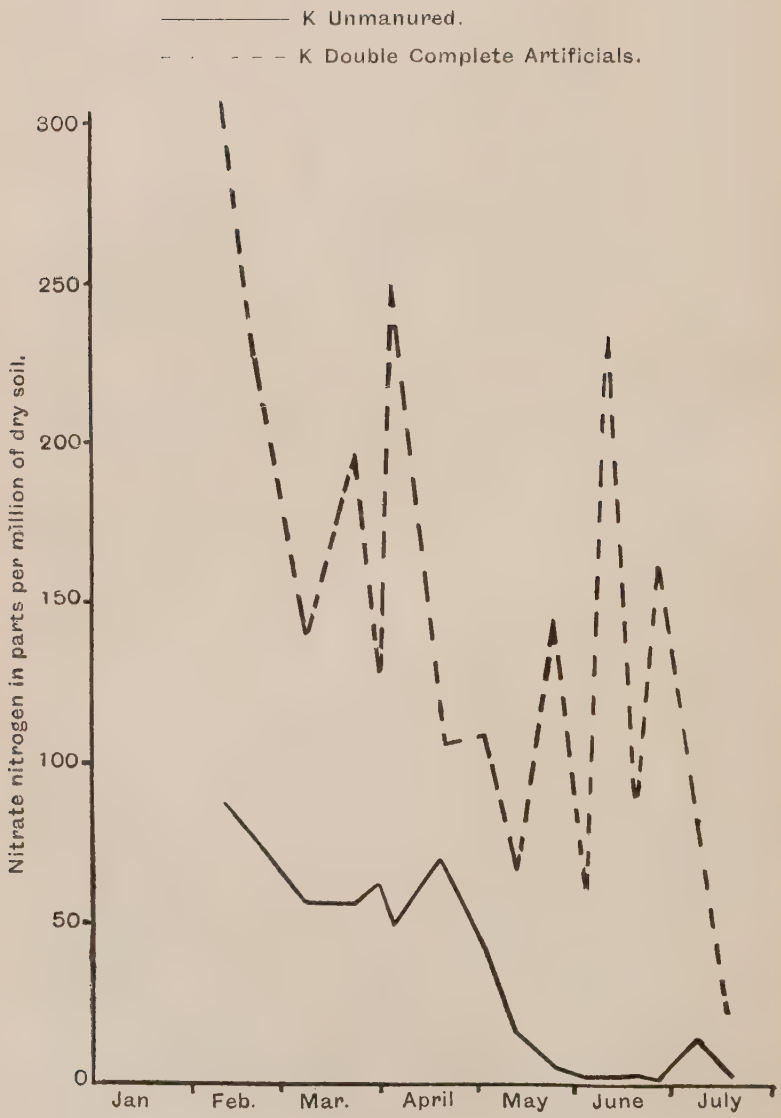

K Unmanured.
K Double Complete Artificials.
Nitrate nitrogen in parts per million of dry soil.
300
250
200
150
100
50
0
Jan
Feb.
Mar.
April
May
June
July

Fig. 3.

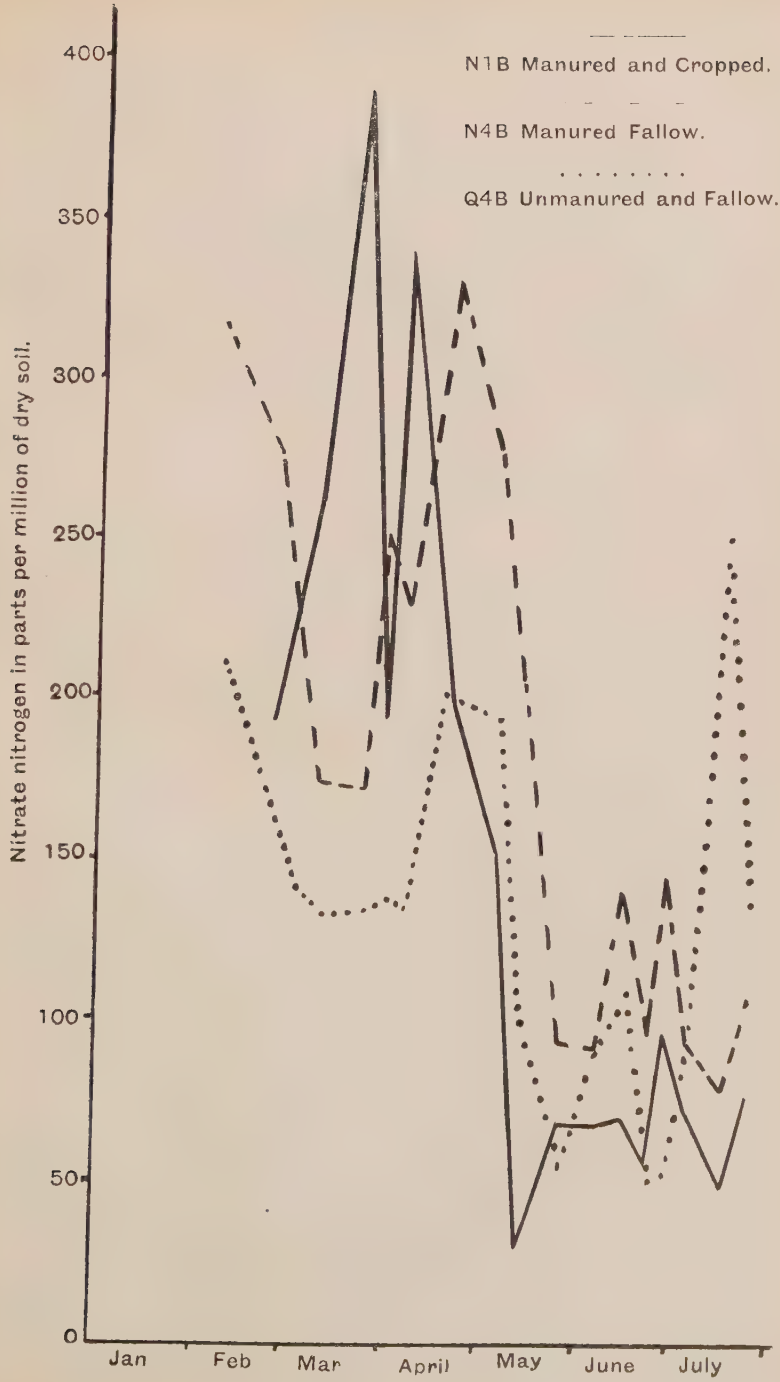

N1B Manured and Cropped.
N4B Manured Fallow.
Q4B Unmanured and Fallow.
Nitrate nitrogen in parts per million of dry soil.
400
350
300
250
200
150
100
50
0
Jan
Feb
Mar
April
May
June
July

Fig 4

**Table 2.**

Houses N. and Q.

Nitrate nitrogen in parts per million of Oven Dried Soil.

| Date. | N1B Cropped. | N4B Fallow. | Q4B Unmanured Fallow. |
|---|---|---|---|
| Feb. 7 ... | — | 317 | — |
| ,, 8 ... | — | — | 210 |
| ,, 24 ... | 192 | 278 | — |
| Mar. 3 ... | — | — | 141 |
| ,, 10 ... | 262 | 173 | — |
| ,, 11 ... | — | — | 133 |
| ,, 24 ... | 392 | 171 | — |
| ,, 25 ... | — | — | 134 |
| ,, 31 ... | 193 | 252 | — |
| April 1 ... | — | — | 138 |
| ,, 6 ... | 340 | 225 | 135 |
| ,, 20 ... | — | — | 202 |
| ,, 21 ... | 198 | 332 | — |
| May 5 ... | 152 | 279 | 193 |
| ,, 13 ... | 28·9 | 205 | 100 |
| ,, 26 ... | 67·7 | 94·0 | 53·3 |
| June 7 ... | 66·7 | 91·6 | 90·7 |
| ,, 14 ... | 68·7 | 142 | — |
| ,, 15 ... | — | — | 109 |
| ,, 22 ... | 55·6 | 95·8 | — |
| ,, 23 ... | — | — | 50·5 |
| ,, 28 ... | 96·8 | 147 | 51·8 |
| July 5 ... | 70·6 | 93·1 | 99·0 |
| ,, 12 ... | 47·7 | 79·2 | 252 |
| ,, 19 ... | 76·6 | 108 | 138 |

The most striking feature of these figures is the way in which the values vary in all the plots. It does not appear to matter what the manurial treatment is or whether a crop is present or not. Those plots in K which receive no manure and no nitrogen respectively show but little variation after the middle of May, but before this time they show fluctuations which all the other plots show.

Another property which all the plots have in common is the tendency to show relatively high nitrate values during the early part of the year before planting. Even in the unmanured plots K2B and the no-nitrogen plot K7B, there are appreciable amounts of nitrogen in this form after the first watering. Planting, and the subsequent early growth of the plants appear to have little effect on the values. All planting was completed by March 14th, but it will be seen that there is no sudden drop in the nitrate values of any of the soils. Since growth, when it begins, is vigorous, it is clear that nitrates are being produced at this stage just as quickly as the plants require them. This is in accord with our

experience of the pickings during June and July. Reference to earlier reports will show that, even on the plot receiving no nitrogen, the crop picked during June and July is generally well up to the pickings during these two months in the plots which receive complete manurial treatment. The curves here given show that, in the early stages, the omission of nitrogen has little effect on the amount of nitrate present. It is probable that in the no-nitrogen plot sufficient of the original nitrogen reserve is still present in a form which can be converted into nitrate during the winter months. The accumulation of nitrate so formed, together with the nitrates formed in the early part of the growing season, are sufficient to supply all the nitrogen the plants require to produce the fruit to be picked during June and July.

By the end of April the first real watering had been given to all the plots. This is immediately reflected in a decided fall in the nitrate values. In the no-nitrogen and unmanured plots the values became very small and varied but little afterwards. In the other plots reductions are evident, but the top dressings given cause the values to fluctuate considerably. In the last Annual Report it was shown that the first watering is followed by a decided increase in the rate of growth. This will mean an increase in nitrogen consumption but it is evident from the curves for the fallow plots that the watering alone is followed by a depression in the nitrate content. The water content of the various soils have been compared with the nitrate content and definite correlation exists between the two values. An increase in the water content of the soil is accompanied by or immediately followed by a depression in the nitrate value. Conversely, a decrease in the water content is accompanied or followed by an increase in the nitrate value. It appears that the process of leaching which follows watering is an extremely important factor in its influence on the nitrate status of these soils.

The effect of manurial treatment is easily followed in the curves. In the older soils of K it is evident that the omission of all manures or of nitrogen only results in a continuous low value after the first watering. The omission of phosphates or of potash, on the other hand, appears to be without any definite depressing effect on the nitrate content. In fact, the figures for these two soils are, on several dates, higher than those for the soil receiving complete artificials. In general, the plot receiving double complete artificials shows higher values than any of the other plots examined in this house. The plots in houses N and Q all show very high values during the early months. It may be remarked here, that house N receives stable manure in addition to complete artificials. The apparent richness of the soil in N may be due to this stable manure, but the excess shown over the complete artificials plot in K is more probably due to the difference in age of the two houses —

N having been in cultivation under glass since 1923 and K since 1915. Q, unmanured and fallow, shows fairly high values and here we probably have an accentuated case of what happens in the no-nitrogen and unmanured plots in K during the winter and early spring. What may be termed the " natural " nitrogen of the soil is being decomposed to nitrates and the only loss has been due to leaching. The disturbance of processes taking place in the soil are at a minimum and, as a result, we have the high nitrate values.

The effect of fallowing on nitrification does not appear to be clear from these determinations. Plots N1B and N5 have received identical manurial treatment since 1923 but whereas N1B has been cropped each year, N5 has remained fallow. It does not seem that any definite conclusion can be drawn from a comparison of the results in the two cases. It is likely that the crop has little effect on the amount of nitrates in the soil since the depression after the first watering is apparent in both cases.

The maximum shown in all the curves during the month of June is, no doubt, related to the top dressings, the first of which was applied about the third week in May.

It appears, then, that, irrespective of treatment there is an accumulation of nitrogen in the form of nitrates during the winter and early spring. The omission of potassic or phosphatic fertilisers is without appreciable effect in nitrification. The growth of the tomato plants in the early stages does not depress the nitrate contents of the soils. Leaching appears to depress the nitrate concentrations and its effect may be sufficiently large to obscure any effects due to other factors. In an " old " soil the nitrate concentration is lower than that on a younger soil.

## 2. The Effect of Manurial Treatment on the Composition of the Foliage of Tomato Plants.

In the Annual Report for 1925 analytical figures were given to show the differences in composition of whole tomato plants in an unmanured soil as compared with those grown in a soil receiving regular applications of complete artificials. As an extension of this work it was considered that the analyses of plants growing in those plots which receive no phosphates, potash and nitrogen respectively might yield useful information. For several reasons it was not possible to use whole plants, and so typical *foliage* was selected from plants in these plots, J5, J6A, J7A, and J8A.

These plots receive complete artificials, complete artificials less phosphates, complete artificials less nitrogen, and complete artificials less potash respectively. The analyses were carried out on samples taken in each of the seasons 1924, 1925 and 1926. To

make the samples comparable leaves were taken from near the fifth truss of plants in each plot in June of each year. Leaves from plots J7A and J8A were showing the typical symptoms of nitrogen and potash starvation respectively. In 1927 samples of foliage were taken from the plots J5A, J5B, J6A, J6B, J6C, J6D, J7A, J7B, J7C, J8A, J8B, J8C, J8D. The manurial treatment of these plots is stated briefly in Table 7. Unfortunately, in this year the samples taken in June were not analysed and samples taken in August were used. The results of the analyses are given in Tables 3 to 7, where all the figures are calculated for the dried foliage.

**Table 3.**

The Percentage of Ash in the Dried Foliage of the Plants.

| Plot. | 1924. | 1925. | 1926. | 1927. |
|---|---|---|---|---|
| J5 (complete) ... | 32·53 | 26·97 | 34·47 | 30·40 |
| J6A (No phosphates) | 36·90 | 25·32 | 32·59 | 34·45 |
| J7A (No nitrogen) ... | 30·55 | 27·69 | 35·43 | 33·28 |
| J8A (No potash) ... | 31·32 | 25·36 | 27·57 | 25·01 |

From Table 3 it will be seen that in each of the four years the omission of sulphate of potash depresses the ash content of the foliage. A further point which may have some significance is that the ash content appears to be uniformly low in 1925 as compared with the other years.

**Table 4.**

The Percentage of Nitrogen in the Dried Foliage of the Plants.

| Plot. | 1924. | 1925. | 1926. | 1927. |
|---|---|---|---|---|
| J5 (Complete) ... | 3·914 | 3·908 | 3·077 | 5·141 |
| J6A (No phosphates) | 3·966 | 3·700 | 2·465 | 4·331 |
| J7A (No nitrogen) ... | 2·393 | 2·210 | 1·737 | 2·905 |
| J8A (No potash) ... | 3·594 | 3·668 | 2·639 | 5·028 |

Perhaps the most striking fact which emerges from Table 4 is that all values for 1926 are low compared with the other years. This may be connected with the low crops obtained from all the plots in that year. In each year, as might have been expected, the omission of nitrogen from the fertilisers caused a decided reduction in the nitrogen content. Smaller reductions are also the case where either potash or phosphates are omitted except in J6A in 1924. In general, then, the omission of any one fertiliser is followed by a reduction in the nitrogen content of the foliage.

**Table 5.**

The Percentage of Potash ($K_2O$) in the Dried Foliage of the Plants.

| Plot. | 1924. | 1925. | 1926. | 1927. |
|---|---|---|---|---|
| J5 (Complete) ... | 6·405 | 5·710 | 8·734 | 7·273 |
| J6A (No phosphates) | 3·753 | 4·661 | 6·990 | 5·592 |
| J7A (No nitrogen) ... | 6·676 | 6·670 | 7·214 | 3·580 |
| J8A (No potash) ... | 2·454 | 1·192 | 1·180 | 1·891 |

The omission of potash from the manure causes a big fall in the amount of potash in the plant. It appears also that the omission of nitrogen produces a similar but not so decided an effect. Of greater interest, however, is the very real reduction in the potash content when phosphates are omitted. It is suggested tentatively that the plants are unable to take up the necessary complement of potash in the absence of a certain minimum amount of phosphates. Whilst the reduction in potash is appreciable the amount absorbed by the plant is still above the limit below which potash starvation sets in.

It will be remembered that, in the Report for 1926, the analyses showed that whole tomato plants growing in and unmanured plot possessed a very low relative potash content. In the soil of this plot both the phosphoric acid and potash were at a low concentration. In view of the foregoing it appears probable that the starved plants take up little potash, not only because there is a reduced amount of potash in the soil, but in addition, the amount of phosphates in the soil is too low to allow the plants to make the maximum use of what potash there is. If this argument is valid increasing amounts of phosphates on soils receiving the same amounts of potash should increase the amount of potash in the foliage. That this is so will be seen from Table 7, which is discussed later.

**Table 6.**

The Percentage of Phosphoric Acid ($P_2O_5$) in the Dried Foliage of the Plants.

| Plot. | 1924. | 1925. | 1926. | 1927. |
|---|---|---|---|---|
| J5 (Complete) ... | ·7307 | ·6817 | ·6992 | ·5577 |
| J6A (No phosphates) | ·6683 | ·5589 | ·6103 | ·5358 |
| J7A (No nitrogen) ... | ·4645 | ·6683 | ·6592 | ·5538 |
| J8A (No potash) ... | ·9959 | ·6717 | ·9506 | ·9436 |

An examination of Table 6 shows that the omission of phosphates from the manure does not cause such a depression in the phosphoric acid content of the foliage as might have been expected.

This points to two possibilities : firstly, that there is still sufficient of the " original " phosphates present in the soil of J6A to allow the plant to take in a reasonable amount and secondly, it confirms a view already put forward in these reports, namely, that the actual phosphoric acid requirements of the tomato plant are low.

It will be seen that where the omission of nitrogen causes an effect it is to depress the amount of phosphoric acid in the foliage.

Except in 1925 the omission of potash causes a decided increase in the phosphoric acid absorbed by the plant. This is in agreement with analyses already reported, and it has already been suggested that when the plants do not take up the potash they require they will absorb an increased amount of phosphates and possibly nitrogen. These figures again support the belief that there is a close interdependence between the potash and phosphates in the soil, and the amounts of these materials utilised by the tomato plants.

A further test of this view was made by an examination of foliage in 1927 of plants in the plots receiving varying amounts of the three nutrients. The results are given in Table 7.

**Table 7.**

The Analyses of Dried Foliage of Plants in the different Plots, 1927.

| Plot and Manurial Treatment. | Nitrogen. | Phosphoric Acid ($P_2O_5$). | Potash ($K_2O$). |
|---|---|---|---|
| J5A (Complete artificials) ... | 5·141 | ·5577 | 7·273 |
| J5B (Complete artificials and grass) ... ... ... ... | 4·938 | ·6232 | 5·639 |
| J6A (potash and nitrogen ; no phosphates) ... ... ... | 4·331 | ·5358 | 5·592 |
| J6B (potash and nitrogen ; 8% phosphates) ... ... | 4·193 | ·6604 | 6·351 |
| J6C (potash and nitrogen ; 16% phosphates) ... ... | 4·567 | ·6443 | 6·520 |
| J6D (potash and nitrogen ; 24% phosphates) ... ... | 4·743 | ·9399 | 6·040 |
| J7A (potash and phosphates ; no nitrogen) ... ... ... | 2·905 | ·5538 | 3·580 |
| J7B (potash and phosphates ; 5% nitrogen) ... ... ... | 4·629 | ·5697 | 5·416 |
| J7C (potash and phosphates ; 7½% nitrogen) ... ... ... | 4·871 | ·5291 | 5·751 |
| J7D (potash and phosphates ; 10% nitrogen) ... ... ... | 5·660 | ·6685 | 6·061 |
| J8A (phosphates and nitrogen ; no potash) ... ... ... | 5·028 | ·9436 | 1·891 |
| J8B (phosphates and nitrogen ; 7½% potash) ... ... ... | 3·841 | ·4414 | 4·163 |
| J8C (phosphates and nitrogen ; 10% potash) ... ... ... | 4·049 | ·4254 | 4·658 |
| J8D (phosphates and nitrogen ; 12½% potash) ... ... ... | 4·334 | ·4648 | 5·669 |

The figures in this Table show quite clearly how the three nutrients affect one another with respect to absorption by the plant. For instance, increase of phosphoric acid or nitrogen in the manure tends to increase the nitrogen absorbed. If we except J8A increase of potash causes the same effect.

Or, again, the potash values in the J plots, all receiving the same amount of potash, show that increase of nitrogen means an increased absorption of potash. The mutual effects of potash and phosphoric acid are amply illustrated. In the plots J6 increases in the amounts of phosphate applied are accompanied by increases in the potash absorbed. This may explain how some growers are able to harden tomato plants by the application of phosphatic fertilisers. Ordinarily plants can be hardened relatively quickly by the application of potash, and this method is to be preferred. According to the results here given it is likely that under certain conditions the application of phosphates would bring about an increased absorption of potash by the plants.

Where *no* potash is added in the manure (J8A) the phosphoric acid content is the highest recorded in the whole series. Where potash is added there results immediately a decided reduction in the phosphoric acid value. In other words, phosphate absorption is replaced by potash absorption, and it would appear that the two nutrients are to some extent mutually replaceable.

The main conclusion of these analyses is that the application or omission of any one of the three nutrients produces effects on absorption by the plants, and these effects are not confined to the absorption of that nutrient alone.

Whilst the full significance of these results cannot be appreciated at present, they do suggest that further work along similar lines will be fruitful. The analyses will be continued, and it is also hoped that they will suggest a method for the determination of the amount of potash and phosphoric acid in the soil available for the tomato plant.

## 3. The Presence of a Chlorate in a Tomato Soil.

The harmful effects produced in a tomato soil by some compounds are described on page 109. Although the chemical investigation of this problem is not yet complete, the following results are given here on account of their general interest and because they show that the compound in question is a chlorate or a mixture of chlorates.

Having decided that the symptoms produced in the plant were due to a chemical substance and not to an organism, it was necessary to decide whether it was of an inorganic or an organic nature. The following facts suggested that the compound was inorganic :

1. An aqueous extract of the soil gave no reaction with either the usual alkaloidal or protein reagents.
2. The toxic substance was not volatile in steam.
3. Organic solvents extracted no more of the substance than did water.
4. Autoclaving a toxic extract for seven hours at 30 lbs. pressure per square inch produced no effect, whilst autoclaving the soil itself for $1\frac{1}{2}$ or 2 hours caused the toxic effects to disappear. If the substance was organic it is probable that under these circumstances it would volatalise in both cases. That it disappears only when heated points to a reaction taking place with other substances present in the soil and not extracted by water.
5. Gentle ignition of either the soil or an evaporated extract caused the toxicity to disappear.
6. Prolonged boiling of an extract with hydrogen peroxide was without effect.

Acting on the assumption that the compound was inorganic, an examination of the extract was made. It was soon evident that the soil was not homogeneous with respect to solids extractable by water. In all extractions, however, more material was water soluble in the toxic soil than in samples of normal soil from the same nursery. The following figures are typical for the soils :—

| | Total Solids Extracted by Water, Per Cent. | Residue after Ignition of Solids, Per Cent. |
|---|---|---|
| Toxic soil ... ... | 0·426 | 0·283 |
| Normal soil ... ... | 0·224 | 0·156 |

Further examination showed that the excess of soluble material in the toxic soil was largely due to sulphates and chlorides. That the toxic effects were not due to chlorides or sulphates was shown in two ways. In the first place, the addition of a corresponding amount of chlorides and sulphates to the normal soil before planting was followed by no deleterious effects in the plants. Secondly, the careful removal of sulphates and chlorides from a toxic extract was without effect on the toxicity. This latter fact eventually led to the identity of the compound.

A toxic extract was treated with sufficient silver nitrate to remove all the chlorides present. After the removal of the insoluble silver chloride the resulting solution was toxic. Evaporation and gentle ignition caused the toxicity to disappear and at the same time caused the reappearance of a halide as shown by the addition of water and silver nitrate. These results suggested that the compound sought was a chlorate or a perchlorate and there was also the lesser probability that it might be a bromate or a hypochlorate. That it was not a perchlorate was shown by the facts that a chloride was produced and the toxicity disappeared after the reduction with ferrous sulphate. The possibility of a hypochlorate and a bromate were removed by the fact that the symptoms are exactly reproduced in plants growing in ordinary soil to which had added sodium or potassium chlorate.

It is interesting to note that when a strong extract corresponding to 100 gms. of the toxic soil is treated with a large excess of 90% alcohol a good deal of the dissolved salts are precipitated but none of the toxic material. Removal of the alcohol from the resulting solution left a mixture which gave the typical chlorate reaction with concentrated sulphuric acid.

The concentration of the chlorate in the soil is variable as the soil is not homogeneous in this respect. Calculated as potassium chlorate the concentration in the soil shown in three different analyses was 0·0193%, 0·0284% and 0·0297%. This last figure was the highest value recorded and was obtained by extracting 300 gms. of soil with twenty-five times its weight of water, namely, 7,500 c.c.

It may be mentioned that addition of perchlorates to soil produces definite symptoms in tomato plants, but that bromates and iodates seem to have no appreciable effect in low concentrations. The origin of the chlorate in this particular soil is problematical and investigations to solve this point are now in hand.

Acknowledgments are gratefully made to Mr. A. L. Holland for his valuable assistance during the course of this investigation.

# 8. A Case of Tomato Injury on a Commercial Nursery.

W. F. Bewley and W. Corbett.

In May, 1927, the assistance of the station was sought by a nurseryman whose tomato plants were suffering severe injury in two houses. The symptoms involved mottling and desiccation of the foliage, combined with a stunted growth and some slight root injury.

Inspection of the nursery showed the injury to be localised in large patches, while here and there between the patches individual plants and small groups of two or three plants were only slightly infected. It was therefore possible to pick out a whole series of plants giving a range of symptoms from severe injury to normal growth.

The worst plants were barely nine inches high and with the exception of a small rosette of mottled leaves at top, the foliage was desiccated ; most of the leaves had fallen to the ground. Pale brown streaks could be seen on the stem and petioles, while brown necrotic areas were also present on the top leaves. Other plants were about two feet tall, and while the symptoms were similar to those previously described, the damage was not quite so severe, although leaf desiccation and fall was usual, and the majority of the flowers failed to set. The least affected plants were only slightly stunted but the foliage was paler than usual, and the areas along the midrib and lateral veins were distinctly yellow. The mottled leaves were distinctly crinkled and the edges showed a tendency to curl. The darker green patches stood out like blisters and there was a general waxy appearance. Sometimes the symptoms closely resembled those of mosaic disease, but experiment has proved that they cannot be induced in healthy plants by any of the standard methods for transferring this disease. On other plants the symptoms resembled those produced by chemical poisons in the soil.

The disorder is of additional importance because plants showing the weak symptoms are frequently found on nurseries, and it seemed probable that the influence at work in this case might be a common source of injury.

Inquiry elicited the information that in the affected houses the ground had been so dug that soil from below a depth of 2 feet was brought to the surface, whereas in the normal houses, the soil had been bastard trenched in the usual manner. The deep soil was dark in colour and gave the appearance of being in bad condition.

The possibility of an accessory factor occurring in mosaic disease has always been kept in mind, and the mosaic-like symptoms exhibited by some of the plants in this case suggested that the injurious influence might have some connection with mosaic disease.

The results discussed below indicate that the harmful influence is not primarily a living organism. They suggested the existence of a chemical poison in the soil, and the problem was given to the chemist for its isolation and identification. His work is described in another section and suggests that the injurious agent is either sodium or potassium chlorate or both.

**Soil Experiments.**

Soil from the tomato houses mentioned in the introduction was brought to the laboratory and used for the following experiments.

**Dilution of Affected Soil with Baked Soil.**

Some of the soil was mixed with normal baked soil in the following proportions :—

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| (1) | Affected soil | 1 | part. | Baked soil | 0 | parts. |
| (2) | ,, ,, | 3 | ,, | ,, ,, | 1 | ,, |
| (3) | ,, ,, | 1 | ,, | ,, ,, | 1 | ,, |
| (4) | ,, ,, | 1 | ,, | ,, ,, | 3 | ,, |
| (5) | ,, ,, | 1 | ,, | ,, ,, | 6 | ,, |
| (6) | ,, ,, | 1 | ,, | ,, ,, | 10 | ,, |
| (7) | ,, ,, | 0 | ,, | ,, ,, | 1 | ,, |

Tomato plants were planted in the above mixtures immediately after mixing. After a period of 48 hours the plants in series (1) and (2) were showing initial symptoms of the affection, and the rate of development of the symptoms in the other series was in direct relation to the amount of contaminated soil present in the mixture.

The first observable symptoms exhibited by plants planted in the affected soil was a browning of the midrib and larger veins of the lower leaves ; this took from 36 to 60 hours to appear. More severe effects followed rapidly and soon the whole plant was affected. The lower leaves became desiccated and dropped off, the upper leaves became mottled and distorted, and the whole plant was stunted.

The plants did not die and in a period of fourteen days the symptoms were as already described.

A further noticeable feature of the experiment was that the severity of the symptoms exhibited by the plants in the different dilutions was in direct relation to the amount of affected soil present.

The experiment was repeated with the exception that the mixed soils were allowed to stand in the pots for fourteen days before planting. The same result was obtained as in the first experiment.

**The Effect of Various Heat Treatments on the Injurious Effect of the Soil.**

**(1) Steaming.**

Pots containing the contaminated soil were steamed at 100°C. for periods varying from half an hour to three hours. After treatment they were allowed to stand for three days before planting. Ten days later all the plants were showing distinct initial symptoms of the trouble, and rapidly became as badly affected as those planted in untreated contaminated soil at the same time.

The experiment was repeated and a nine day interval allowed before planting. Again all the plants were showing distinct initial symptoms of the injury in three days, and as before, the symptoms soon became of the severest type.

**(2) Antoclaving.**

Pairs of size 60 pots filled with the contaminated soil were antoclaved at 30 lbs. pressure (140°C.) for periods varying from half an hour to three hours. After treatment three days were allowed to elapse before introducing tomato plants.

A second series treated as above were washed well with water before planting.

Plants were also planted in untreated contaminated soil and baked soil to serve as controls.

In all cases where the soil had been antoclaved the plants grew away without showing the slightest symptoms of the affection, the plants in untreated soil exhibiting the most severe symptoms in four days.

It was suggested that the good effect of antoclaving might be due in part to steam washing, and the following experiment was suggested. Sufficient of the affected soil for two size 60 pots was placed in a tin and antoclaved, together with two size 60 pots containing affected soil, at 30 lbs. pressure per sq. in. for a period of half an hour. After treatment the soil from the tin was put into two clean pots and, after standing for three days, these and the two pots with soil which had been antoclaved were planted with tomato plants.

In this case, as before, none of the plants showed any symptoms of the affection despite the fact that those in the soil antoclaved in the tin did not grow away as quickly as those in the soil which had been antoclaved in pots.

As will be seen from the results of experiments described later, it was found necessary to repeat these antoclaving experiments several times. The same result was always obtained, antoclaving the soil at 30 lbs. pressure (140°C.) destroyed or removed the injurious principle.

**(3) Ignition.**

A weighed quantity of the contaminated soil was subjected to heat until all the organic matter was ignited and the residue assumed a brick-red colour. The loss in weight was made up with normal baked soil. Tomato plants were planted in this treated soil and also in untreated contaminated soil as a control.

The plants in the ignited soil grew away without exhibiting the least symptoms of the affection, whereas the control in untreated soil developed the most severe symptoms in four days.

**The Effect of Washing the Soil.**

1,200 gms. of the affected soil were washed with 1 litre of water, the operation being repeated five times ; the last washings were filtered through a Buchner funnel. The soil was then air-dried and tomato plants were planted in it. After a period of sixteen days the plants were showing slight symptoms of the affection.

A further experiment was carried out in which affected soil was put in a series of size 60 pots and washed with varying quantities of water, from 200 c.cs. to 4,000 c.cs., before planting. After the pots had been allowed to stand for some time so that the soil might dry, tomato plants were planted in them. Plants were also planted in unwashed affected soil as controls.

The latter plants developed initial symptoms of the affection within a period of two days. After a period of four days the plants in soil washed with 200 c.cs., 400 c.cs., and 600 c.cs., of water respectively were also showing initial symptoms of the affection which quickly developed into the most severe symptoms. After a period of fourteen days the plants in soil washed with 2,000 c.cs. and 4,000 c.cs. of water respectively were showing slight symptoms of the affection, but did not become more severely affected.

**The Effect of Various Chemicals.**

The effect of various chemical compounds and manures on the affected soil was investigated. Among those used in the following experiments were lime, hydrochloric acid, potassium permanganate, lead acetate, ammonium sulphate, gypsum, copper sulphate, mercuric chloride, sodium chloride, potassium sulphate, superphosphate, Cheshunt compound and hydrogen peroxide.

In the first experiment affected soil was put into size 60 pots and then treated with the above-mentioned compounds by watering on to the soil aqueous solutions of strengths varying from 0.01% to 0.1%. In the case of hydrochloric acid and potassium permanganate 20 c.cs. of solution only were used per pot ; in all other cases 100 c.cs were used. In the case of lime, the soil was mixed with powdered lime in proportions of from 0.1% to 5.0% of lime.

In another experiment 350 gm. portions of the soil were weighed into flasks and treated with 350 c.cs each of a 0.4% solution of the above-mentioned compounds except in the case of mercuric chloride when a 0.2% solution was used. On the solution being added to the soil in the flasks they were well shaken and then allowed to stand for twenty-four hours, after which the solution was filtered off.

The residual soil was air-dried and then tomato plants were planted in it, and 50 c.c. portions of the filtrate were watered on to tomato plants growing in baked soil. The whole experiment was carried out in duplicate.

In both experiments ammonium sulphate was the only substance with any beneficial effect. Lime seemed to intensify the symptoms.

**Extraction of Soil with Various Solvents.**

**(1) Water Extracts.**

In the following experiments the extract was made by shaking 1,000 gms. of affected soil with 1,000 c.cs. of water for half an hour, allowing to stand for a period and then decanting and filtering the supernatant liquid. By watering some 50 c.cs. of an extract made in this way on to a tomato plant growing in normal baked soil typical symptoms of the affection appeared in upwards of sixty hours.

**(a) Effect of Dilution.**

Tomato plants growing in normal baked soil were watered with 50 c.cs. of varying concentrations of water extract from 10% to 100%. Plants watered with all concentrations from 30% upwards were showing typical symptoms of the affection in seventy-two hours, while those watered with the 10% and 20% concentrations were quite healthy after fourteen days.

**(b) Effect of Steaming and Antoclaving.**

100 c.c. portions of water extract were steamed in flasks for periods varying from half-an-hour to four hours. After cooling, 50 c.c. portions from each flask were watered on to tomato plants growing in normal baked soil. In a period of four days all the treated plants were showing severe symptoms of the affection.

100 c.c. portions of water extract were antoclaved at 30 lbs. pressure for periods varying from half-an-hour to four hours. After cooling, 50 c.c. portions of treated extract were watered on to tomato plants growing in normal baked soil, and four days later all the treated plants were showing severe symptoms of the affection.

This experiment was repeated several times with the same result. Thus, while the soil can be improved by antoclaving, a soil solution remains unaffected.

**(2) Organic Solvents.**

From experiments carried out it would appear that the injurious principle is partially removed from the soil by acetone and alcohol, but little or none is removed by ether, chloroform, and carbon di-sulphide.

**The Effect of the Soil on Various Plants.**

A number of different kinds of plants were planted in this soil, the results being set out in the following table :—

| Plant. | Effect after 3 Days. | Effect after 10 Days. |
|---|---|---|
| Sweet Pea ... | Pale discolouration of veins of leaves | |
| French Bean ... | Slight scorch ... | Lesions on stem, suggesting "Stripe." Severe scorch. |
| Tobacco ... ... | Severe scorch of lower leaves | |
| Begonia (tuberous) | No effect ... ... | Slight mottling and scorch |
| Melon ... ... | Severe scorch. | |
| Kale ... ... | Slight paling of lower leaves | Slight mottling of upper leaves |
| Cineraria ... ... | Browning of veins and slight scorch | Severe scorch |
| Cabbage ... ... | No effect ... ... | No effect |
| Beet ... ... | Discolouration of veins | Bad discolouration and wilting |
| Onion ... ... | Yellowing and wilting of leaves | Severe |
| Chrysanthemum | Very severe scorch | |
| Raspberry (suckers) | Severe scorch | |
| Solanum nigrum ... | Mottling and necrosis of veins | |
| Lettuce ... ... | No effect ... ... | Slight mottling and blistering, indistinguishable from Mosaic |

It will be seen from the preceding table that most plants are affected by this soil, the cabbage only remaining unaffected, even after twenty-one days.

**Transmission of the Symptoms to Healthy Plants.**

**Inoculation Methods.**

The methods usually employed in the transmission of mosaic disease are (1) the injection of the extracted juice of an affected plant into the leaves and stems of healthy plants, and (2) the insertion of pieces of crushed leaf tissue from an affected plant into the stems of healthy plants.

Healthy tomato and tobacco plants were inoculated, with extracted juice, and crushed leaf tissue of plants grown in the affected soil, while others were inoculated with mosaic tissue and juice at the same time. In a period of eleven to fourteen days the plants inoculated with mosaic all showed symptoms of the disease, whilst those inoculated from plants grown in the affected soil were all healthy. A fortnight later these plants were still healthy.

A noticeable feature of the individuals inoculated with the juice of plants grown in affected soil was the local effect of the inoculation around the point of inoculation. A pale green area was produced around each inoculation point ; this paling did not spread but the tissues within the area eventually became desiccated and died.

Attempts were also made to transmit the affection to healthy broad bean, culinary pea, sweet pea and clover plants. Apart from a local effect around the points of inoculation all the plants remained healthy throughout the experiment.

**Grafting.**

As some virus diseases can only be transmitted to healthy plants by grafting, diseased scions were grafted on to healthy stocks and healthy scions on to diseased stocks. In the former case the scions grew away quite healthy, whilst in the latter case the healthy scions became affected.

**Cuttings.**

When the tops of affected plants were taken as cuttings and inserted in baked soil and in sand, they rooted freely and grew away quite free from the affection.

**The Effect of Watering the Extracted Juice on to Plants Growing in Baked Soil.**

In this experiment six plants, which had been grown in the contaminated soil and were exhibiting severe symptoms of the affection, were crushed in a mortar and the juice extracted by squeezing through muslin. The juice so obtained was diluted to 200 c.cs. with distilled water and two healthy plants growing in baked soil were watered, 100 c.cs. per plant.

After a period of three days the two plants were showing decided initial symptoms of the affection which rapidly became severe.

A further experiment was carried out in which two affected plants only were treated as before and the extracted juice made up to 200 c.cs. with distilled water and watered on to two healthy tomato plants growing in baked soil.

Again in a period of three days the two plants watered with the diluted extract were exhibiting typical initial symptoms of the affection, more severe symptoms following quickly.

Such results suggest that the poison is taken up into the plant unchanged.

**Conclusions.**

(1.) A case of failure of the tomato crop has been investigated.

(2.) The symptoms in the most severe form were stunted growth, a mottling and desiccation of the foliage, browning of the stem and petioles in patches and some root injury. In some cases the mottled foliage was not unlike that caused by mosaic disease.

(3.) The diseased condition was not transmitted to healthy plants either by juice inoculation, tissue inoculation or grafting.

(4.) The injury was traced to the presence of some harmful principle in the soil, described in another section of the report.

(5.) The harmful effect was removed by igniting the soil, antoclaving at a temperature of 140°C., and by repeated washing.

(6.) Similar symptoms were induced in a number of plants by cultivation in the nursery soil.

(7.) Steam sterilisation followed by flooding heavily with water should correct this injurious soil condition.

APPENDIX A.

## Manurial Treatment in the Tomato Experiments.

**(1) Lime.**

All Series except Q received 2 tons Ground Caustic Lime per acre.

**(2) Stable Manure.**

Series G, M, N, O, and P received 30 tons of Stable Manure per acre.

**(3) Base Fertiliser.**

Series G and M received $\frac{3}{4}$-lb. per sq. yd. of the following mixture :—

1 part Bone Meal.
1 part Bone Flour.
1 part Ground Hoof and Horn.
1 part Sulphate of Potash.

Series N, O, and P received the following per sq. yd. :—

$\frac{1}{4}$-lb. Bone Meal.
$\frac{1}{4}$-lb. Bone Flour.
$\frac{1}{4}$-lb. Sulphate of Potash.

Series H, steamed for 1927, received $\frac{1}{4}$-lb. Sulphate of Potash per sq. yd. only.

**(4) Top-dressing.**

Series G, H, M, N, O, and P received 2-oz. per sq. yd. of the following mixture every 14 days at discretion :—

3 parts Sulphate of Ammonia.
2 parts Dried Blood.
7 parts 30 % Superphosphate.
5 parts Pure Dissolved Bones.
$\frac{1}{2}$ part Bone Flour.
$2\frac{1}{2}$ parts Sulphate of Potash.

This gave 5 % Ammonia, 24 % Total Phosphates, 12 % Soluble Phosphates, and 7 % Potash on examination.

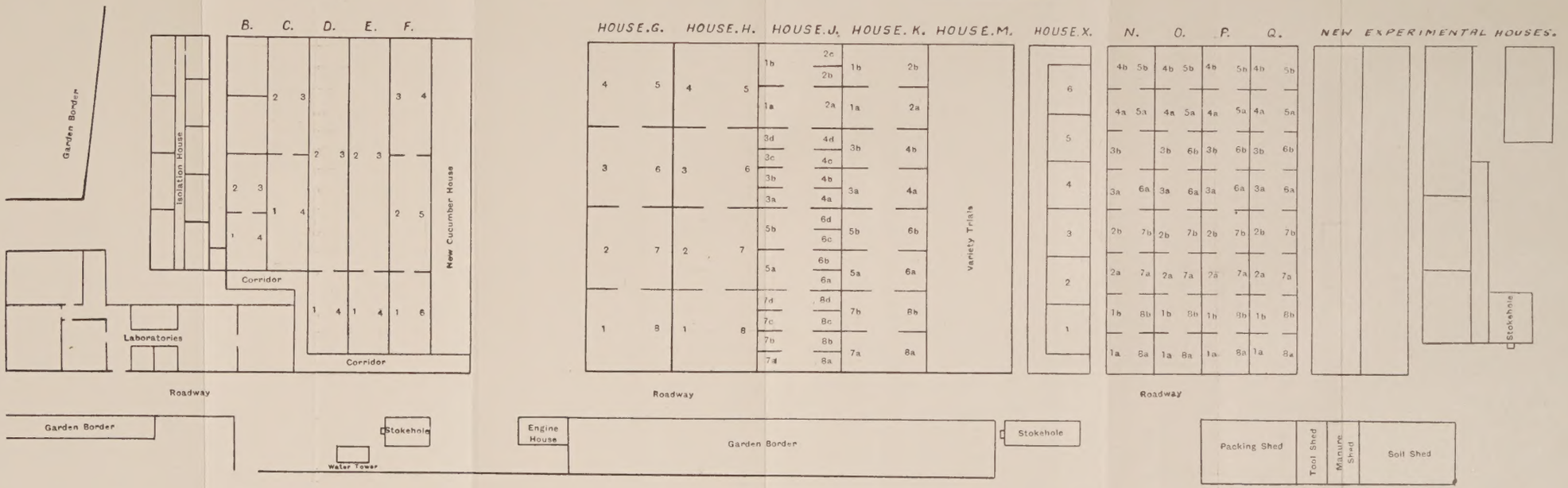
## Manures applied in Series J and K.

| Plot. | TITLE. | Base Manure in Lbs. per sq. yd. | | | | | | | † Top-dressing in Lbs. per sq. yd. | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Lime. | Stable Manure. | Basic Slag. | Bone Meal. | Bone Flour. | Ground Hoofs. | Sulphate of Potash. | Super-phosphate. | Sulph. of Ammonia. | Nitrate of Soda. | Sulph. of Potash. |
| §J2a | Unmanured | 1.0 | — | — | — | — | — | — | — | — | — | — |
| J2b | Unmanured | 1.0 | — | — | — | — | — | — | — | — | — | — |
| J2c | Stable Manure | 1.9 | 28 | — | — | — | — | — | — | — | — | — |
| J3a | Sulphate of Potash only | 1.0 | — | — | — | — | — | — | — | — | — | 0.4 |
| J3b | 2½% Nitrogen and 10% Potash | 1.0 | — | — | — | — | — | — | — | 0.2 | — | 0.4 |
| J3c | 5% Nitrogen and 10% Potash | 1.0 | — | — | — | — | — | — | — | 0.4 | — | 0.4 |
| J3d | 7½% Nitrogen and 10% Potash | 1.0 | — | — | — | — | — | — | — | 0.6 | — | 0.4 |
| J4a | Sulphate of Potash and Superphosphate | 1.0 | — | — | — | — | — | — | 0.3 | — | — | 0.4 |
| J4b | 2½% Nitrogen, 5% Superphosphate, 10% Potash | 1.0 | — | — | — | — | — | — | 0.3 | 0.2 | — | 0.4 |
| J4c | 5% Nitrogen, 5% Superphosphate, 10% Potash | 1.0 | — | — | — | — | — | — | 0.3 | 0.4 | — | 0.4 |
| J4d | 7½% Nitrogen, 5% Superphosphate, 10% Potash | 1.0 | — | — | — | — | — | — | 0.3 | 0.6 | — | 0.4 |
| J5a | Complete Artificials (Formula II.) | 1.0 | — | 0.4 | — | — | — | 0.1 | 1.3 | 0.4 | — | 0.3 |
| J5b | Complete Artificials and Grass | 1.0 | — | 0.4 | — | — | — | 0.1 | 1.3 | 0.4 | — | 0.3 |
| J6a | Complete Artificials (II.) without Phosphates | 1.0 | — | — | — | — | — | 0.1 | — | 0.4 | — | 0.3 |
| J6b | Complete Artificials (II.) with 8% Phosphates | 1.0 | — | — | — | — | — | 0.1 | 0.8 | 0.4 | — | 0.3 |
| J6c | Complete Artificials (II.) with 16% Phosphates | 1.0 | — | — | — | — | — | 0.1 | 1.3 | 0.4 | — | 0.3 |
| J6d | Complete Artificials (II.) with 24% Phosphates | 1.0 | — | — | — | — | — | 0.1 | 1.7 | 0.4 | — | 0.3 |
| J7a | Complete Artificials (II.) without Nitrogen | 1.0 | — | 0.4 | — | — | — | 0.1 | 1.3 | — | — | 0.3 |
| J7b | Complete Artificials (II.) with 5% Nitrogen | 1.0 | — | 0.4 | — | — | — | 0.1 | 1.3 | 0.4 | — | 0.3 |
| J7c | Complete Artificials (II.) with 7½% Nitrogen | 1.0 | — | 0.4 | — | — | — | 0.1 | 1.3 | 0.6 | — | 0.3 |
| J7d | Complete Artificials (II.) with 10% Nitrogen | 1.0 | — | 0.4 | — | — | — | 0.1 | 1.3 | 0.8 | — | 0.3 |
| J8a | Complete Artificials (II.) without Potash | 1.0 | — | 0.4 | — | — | — | — | 1.3 | 0.4 | — | — |
| J8b | Complete Artificials (II.) with 7½% Potash | 1.0 | — | 0.4 | — | — | — | — | 1.3 | 0.4 | — | 0.3 |
| J8c | Complete Artificials (II.) with 10% Potash | 1.0 | — | 0.4 | — | — | — | — | 1.3 | 0.4 | — | 0.4 |
| J8d | Complete Artificials (II.) with 12½% Potash | 1.0 | — | 0.4 | — | — | — | — | 1.3 | 0.4 | — | 0.6 |
| *K1 | Double Complete Artificials (Formula I.) | 1.0 | — | 0.8 | — | — | — | 0.2 | 1.0 | 0.4 | 0.4 | 0.4 |
| K2 | Unmanured | 1.0 | — | — | — | — | — | — | — | — | — | — |
| K3 | Complete Artificials (I.) with Standard | 1.0 | 14 | 0.4 | 0.5 | 0.5 | 0.5 | 0.6 | 0.5 | 0.2 | 0.2 | 0.2 |
| K4 | Complete Artificials (I.) with Dung | 1.0 | 7 | 0.4 | — | — | — | 0.1 | 0.5 | 0.2 | 0.2 | 0.2 |
| K5 | Complete Artificials (I.) | 1.0 | — | 0.4 | — | — | — | 0.1 | 0.5 | 0.2 | 0.2 | 0.2 |
| K6 | Complete Artificials (I.) without Phosphates | 1.0 | — | — | — | — | — | 0.1 | — | 0.2 | 0.2 | 0.2 |
| K7 | Complete Artificials (I.) without Nitrogen | 1.0 | — | 0.4 | — | — | — | 0.1 | 0.5 | — | — | 0.2 |
| K8 | Complete Artificials (I.) without Potash | 1.0 | — | 0.4 | — | — | — | — | 0.5 | 0.2 | 0.2 | — |

* Half of each plot received 14 lbs. Grass Cuttings per sq. yd. in addition. † The Top-dressing was applied in eight equal instalments.

§ J1a—J1d see footnote to Table 3, page 20.

# Diagram showing arrangement of Experimental Plots. 1927.



## Appendix C.

### Dates of Cultural Operations during 1926—1927.

| Crop. | Sown. | Potted into 60's. | Potted into 32's. | Planted out in borders. | First Mulching. | First Top Dressing. | First Fruit Picking. | Last Fruit Picking. |
|---|---|---|---|---|---|---|---|---|
| Tomatoes ... ... | Dec. 31 1926 | Jan. 31 1927 | —— | Mar. 14 1927 | —— | May 5 1927 | May 27 1927 | Oct. 14 1927 |
| Cucumbers ... ... | Dec. 31 1926 | Jan. 10 1927 | Feb. 4 1927 | Feb. 21 1927 | Mar. 16 1927 | April 4 1927 | Mar. 30 1927 | Oct. 14 1927 |

## Appendix D.

### Meteorological Records, 1927.

| Month. | Rain. | | Average outside Temperatures. | | Bright Sunshine. |
|---|---|---|---|---|---|
| | Total fall. Inches. | No. of Rainy Days. | Day Maxm. °F. | Night Minm. °F. | Daily average in hours. |
| January ... ... | 1.71 | 19 | 45.8 | 34.7 | 1.27 |
| February ... ... | 3.54 | 15 | 45.1 | 34.5 | 1.50 |
| March ... ... .. | 2.42 | 17 | 53.6 | 39.6 | 3.65 |
| April ... ... ... | 1.74 | 13 | 57.3 | 40.4 | 5.82 |
| May ... ... .. | 1.37 | 10 | 65.1 | 44.8 | 7.16 |
| June ... ... ... | 2.97 | 18 | 66.1 | 48.8 | 5.60 |
| July ... ... ... | 2.26 | 19 | 69.0 | 55 0 | 4.14 |
| August ... ... ... | 3.75 | 21 | 70.5 | 55.5 | 5.65 |
| September ... ... | 4.82 | 16 | 62.9 | 49.5 | 3.26 |
| October... ... ... | 1.78 | 14 | 58.7 | 44.2 | 3.06 |
| November ... ... | 2.30 | 15 | 48.2 | 37.6 | 1.36 |
| December ... ... | 3.35 | 12 | 39.3 | 32.5 | 0.89 |
| Total or Mean... ... | 32.01 | 189 | 56.8 | 43.1 | 3.63 |